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MARS DURING THE LATE OPPOSITION.

BY JOHN BROWNING, F.R.A.S.

(With a Coloured Plate.)

Though Mars is, with the exception of Mercury, the smallest of the chief planets in the solar system, exceeding but little in magnitude Titan, the sixth of Saturn's satellites, yet it has always excited great interest, from the fact of its being the only planetary body which in its physical conformation bears a close resemblance to that of our earth.

With a good telescope we see its surface mapped out into what are believed to be continents and seas, though these would seem to be distributed in the contrary order to that which they occupy on our globe—the great seas being situated near the poles of the planet, while a broad belt of land surrounds it at the equator. Near the poles, but not corresponding exactly with them, are seen ice and snow, which melt as the poles are respectively presented more directly towards the sun. Like our earth, Mars has a cloudy atmosphere, betokening the presence of both air and water.

The accompanying drawings of Mars, so beautifully rendered in colours, were made in Mr. Barnes's Observatory, at Upper Holloway, with his telescope, an equatoreal reflector of my own make, having a silvered-glass speculum, 8½ inches in diameter, which was parabolised for me by Mr. With. Achromatic eye-pieces of positive construction were alone employed. The power used was generally 300, but, occasionally, on nights when the air was unusually steady, I have used powers as high as 600, with great advantage.

Many persons who have seen the original drawings, have addressed such questions to me as these:—But, did you get such definition as you have represented? Could you really make out all those details? To answer these questions I must describe the method I adopted in making the drawings.

A number of circles were previously prepared, each being a

white disk on a black ground. On looking at the planet through the telescope, it frequently happened that only the general character of the markings upon it were discernible. The most prominent of these markings were at once noted on one of the prepared circles, as quickly as possible, consistent with accurate estimation and determination of their position. It is important that this portion of the work should be promptly executed, because the *position* of the markings rapidly changes with the rotation of the planet.

Having obtained the outline of the principal markings in the manner above described, intervals of good definition were watched for, and upon their occurring, details of minuter markings, colours, and shadows were successively filled in, until in about an hour the drawing was completed.

It will be understood that a drawing made in the manner stated will show many features of interest that would escape notice in a cursory observation. It will, in fact, represent the most that can be made out by patient watching, with a telescope of the aperture employed on the particular night.

In the present drawings the planet is shown as it was seen in the telescope. As inverting eye-pieces were alone used, the lower white markings always represent the ice or snow on the north pole of the planet, while the smaller light patches on the upper part of some of the disks indicate the ice near the south pole. I have made nearly thirty sketches at the telescope, but I have carefully copied only thirteen. These were all made when the air was tolerably steady, and the definition so good that I could work well with powers above 200. Of this number eight of the most interesting have been selected for representation.

When several sketches were made on the same evening, they were taken at intervals of two hours, if the weather permitted. In only one instance have I failed to make out that the form of the markings was permanent, due allowance being made for the effect of perspective in foreshortening them as they approached the edge of the disk.

It is highly probable that in the view of the planet taken on February 16th, at 6·45, the two pointed markings on the extreme left, one above, and the other below the equator, would have been seen united if they could have been observed when they were on the centre of the disk. This drawing would then have agreed pretty closely with one of Mr. Dawes's views engraved in the "Astronomical Register" for September, 1865.

The colour of the body of Mars I have found vary from rose-madder to burnt ochre, the colour appearing ruddiest when there was most mist in our atmosphere. The comparative absence of the ruddy colour towards the edges of the

disk of the planet, Mr. Norman Lockyer has ascribed to the presence of clouds in the planet's own atmosphere.

Mr. Huggins in his valuable paper on the "Spectrum and the Colour of Mars" ("Monthly Notices of the Astronomical Society," March 8, 1867), has referred the absence of colour at the edges of the planet to some peculiar effect of the surface of the planet itself. That the ochreish colour is due to some peculiarity in the surface is, I think, almost proved by Mr. De la Rue's exquisite drawings of Mars, as in these markings of that tint are seen with definite outlines. As I have said, when our atmosphere is free from mist the colour of the equatoreal part is pale, and has not nearly so strongly marked a ruddy tint. This is accounted for by supposing that mist stops the most refrangible rays of light, that is, those towards the blue end of the spectrum, whose waves have the greatest velocity; the red light thus being allowed to preponderate.

When observed under these conditions, the edges of the disk appear Naples yellow, the centre orange, tinged with burnt ochre, while the parts immediately under the dark markings, near the south pole, are whitish, with a tinge of salmon colour. The colour of the dark markings on Mars has been described as greenish or bluish grey; they always appear bluish grey to me, and with this colour I have depicted them. Occasionally the north polar ice has been seen strongly tinted with a bluish colour. I have examined the spectrum of the planet with a direct-vision spectroscope, fitted in the eye-piece of a telescope; the spectrum of the dark markings presented no distinctive peculiarity. This would scarcely prove the entire absence of a blue or greenish shade of colour in the markings, as I have found that if white light be reflected five or six times from surfaces of metallic silver, and then received on white paper, it will be strongly tinged with a chocolate colour. Yet if the light reflected from white paper thus illuminated be examined by means of a spectroscope, no appreciable difference can be seen between the spectrum of this light and that of white light.

In consequence of the effect of irradiation, I have not been able to make out satisfactorily the outline of the north polar ice. I have frequently seen faint white spots appear on the disk, and as these spots approached the edge of the disk, they increased in brilliancy, until, when nearly at its extreme edge, they almost rivalled the polar snows in whiteness; these white cloudy patches never had any definite outlines. They were generally nearly circular in form, and they always appeared in the region of the equator. One of these white cloudy spots I have shown in the sketch taken on February 8th, at 10.30. The spot is represented passing off the left hand edge of the disk.

Mr. De la Rue has shown the dark markings near the south pole as darkest towards the edge nearest to the centre of the planet, and just below the edge of the dark markings the ruddy colour of the body as much fainter than it is nearer to the centre of the body about the equator. I see these appearances distinctly.

In the drawing taken on January 28th, at 9h, a number of breaks will be seen in the edge of the dark marking near the south pole, and forming a series of light streaks directed towards the pole. Mr. Barnes also sketched this appearance, without seeing my sketch, and as, with the exception of a slight difference in the angle given to the light streaks, the two sketches agreed, I cannot have been mistaken in their appearance having been as I have drawn and described them.

On the 31st of March, at 7h, I obtained an exact repetition of the markings in precisely the same position shown in the drawing taken on February 23rd at 9h.; the two drawings coincide so perfectly that I can only distinguish between them by the dates affixed to them. In these two drawings the mark usually termed the hour-glass mark is represented as having just passed the centre of the disk of the planet. The movement, in the time I have stated, includes a period of 35 revolutions, and the time of a single revolution on its axis deduced from the observed recurrence, would be 24h. 38m. 8s. Beer and Mädler, who have observed the largest number of revolutions, give the period of rotation as 24h. 37m. 23s. My own determination is, however, less than Sir Wm. Herschel's.

Could a repetition of the markings in exactly the same position have been observed after a much greater number of revolutions had been completed, a period of revolution more closely accordant with B. and M.'s determination would probably have been obtained. The very unfavourable weather we have had to contend with for some months, has, I regret, rendered a repetition of the observations impossible.

I have said elsewhere that between my own drawings, Mr. De la Rue's, and Mr. Dawes's, there exists a great similarity, and to one of Secchi's drawings one of mine has a considerable resemblance, but I cannot trace a likeness between any of my views and those of Beer and Mädler. This observation leaves on the mind a suspicion that in the course of time some change may have taken place. With regard to the point that no flattening of the planet at the poles has been detected, even by that admirable observer, Mr. Dawes, I would remark that although if the sphere of the planet were oblate to the extent of one-sixteenth, or one-tenth of its diameter, as in the case of Jupiter and the globe of Saturn, the flattening might be easily discerned, yet, if the flattening should not exceed, in proportion,

that of the earth, as would probably be the case from its having nearly the same axial velocity, we could not hope to perceive it, for, under such circumstances, the flattening of the disk of Mars would not exceed twelve miles, and this when the planet is nearest to us, would subtend an angle of only one-tenth of a second.

Professor Phillips's drawings of Mars, of which three are engraved in the "Proceedings of the Royal Society," No. 55, were taken when the north pole of Mars was invisible. Allowing for the difference produced by this cause, the drawings agree with mine in the general form of the markings, but the white margin which I only see in the bays, Professor Phillips shows completely fringing the whole of the markings.

Now half a second is the smallest amount of difference in diameter we could hope to detect, even by the aid of the most delicate micrometric apparatus. The double-image micrometer, devised by the Astronomer Royal, would be the best to employ for this measurement.*

No satellite attending on Mars has yet been discovered. Pursuing the analogy between the planet and our earth, if such a satellite existed of a size proportionate with our moon, as it would be one-quarter the diameter of the primary, we might expect it to be easily visible, but should a satellite exist, not exceeding in size proportionately the second satellite of Jupiter, it would only be visible in very powerful instruments, still it would not, I think, have escaped the notice of the persistent observers who have searched for it hitherto vainly.

The discovery of a satellite to Mars is looked for with interest, as the effect of the sun and the primary in producing perturbations of a satellite would enable the density and mass of the planet to be accurately calculated. At present these are only imperfectly known, but the density is considered to be almost exactly the same as that of the earth.

Unfortunately, observations of value can scarcely be made upon this difficult planet with telescopes of less than six inches aperture, and, unless the observer has extremely good sight, eight or ten inches will be found necessary. During the next opposition I hope to be able to continue my observations with an instrument having a silvered glass speculum twelve inches in diameter.

* In measuring, micrometically, the diameter of Mars, it is very difficult to avoid obtaining too large a result for the polar diameter, the effect of the irradiation causing the white spots near the poles to appear to project slightly from the disk of the planet. The best method, probably, of overcoming this difficulty is by using a single reflecting solar eye-piece.

THE FUNCTIONS OF THE BLOOD.

BY C. W. HEATON,

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EVERY one who has looked through a microscope at a drop of blood, knows that the red or purple colour is confined to certain minute discs, which resemble pieces of money in form, and which float in a clear yellow liquid. The discs are known to physiologists as the *blood-corpuscles*, and the liquid as *liquor-sanguinis*. Both these constituents of the blood have their own specific functions to fulfil in the operations of life, and both have been the subject of numberless researches. Very much still remains to be done; but it is not too much to assert that this most wonderful of liquids is slowly yielding up its secrets to the patient workers who have so long sought for them in vain, and that "the blood, which is the life" of the animal, is no longer the utter, hopeless mystery which it has for ages remained.

Careful microscopic measurements have been made of the size of the corpuscles in the blood of different animals, and it is now generally agreed that in the human subject their average length is 1-3200th of an inch, and their thickness 1-12400th of an inch. Hence it would be possible, if they were packed close together, for 8,126,464 to lie in the compass of one cubic millimetre—a space not larger than a good-sized pin's head. Now the corpuscles occupy, in the aggregate, about one half of the volume of the blood,* and we are, therefore, able to form a good guess at their probable number. Vierordt and Welker have, indeed, gone through the laborious process of counting them; and the former fixes their number at 5,069,000, and the latter at 4,600,000, in the cubic millimetre. It will be seen that these figures agree tolerably well with the rough calculation founded on the size of the corpuscles, and we are, therefore, forced to admit that the tiny red drop obtained from the finger by the prick of a needle, may contain four or five millions of these curious bodies. Such figures, however, give but vague ideas to the mind. A more distinct one is, perhaps, conveyed in the fact, that a room sixty feet long, thirty feet wide, and fifteen feet high, could not contain as many grains of corn as there are corpuscles in a single teaspoonful of human blood, the number being, approximately, eighteen thousand millions!

* This is, of course, only a rough approximation. Their quantity varies extremely in different parts of the body, and even at different times of the day.

It is still doubtful whether the corpuscles consist of red liquid, enclosed by a membrane, or whether they are semi-solid, and of uniform structure throughout. Two of the latest investigators, Max Schultze and Ofsiannikof, assert directly opposite opinions upon this point. Whatever they be, however, it is at least certain that they possess a definite term of life. They are incessantly being formed in the chyle and lymph, and also probably in the liver and some other glands. And after the completion of their work, they disappear or are destroyed, this destruction being seen most remarkably in the liver, and in the blood which has traversed muscular tissue.*

The chief function of the blood-corpuscles in the body has long been known, or, at any rate, strongly suspected. They are the carriers of oxygen, the agents of oxidation, in the animal body. During its passage through the lungs, the blood, as every one knows, loses carbonic acid and takes up oxygen. Every 100 volumes of the blood which enters the lungs is capable, according to Claude Bernard, of absorbing twenty-one volumes of oxygen. This is about seven times as much as an equal quantity of water could dissolve, and Berzelius, long ago, showed that serum, which differs but slightly from liquor-sanguinis, was hardly superior to water in this respect. Consequently, it is evident that the great mass of the oxygen must be attracted by the blood-corpuscles. The corpuscles, as before mentioned, constitute about one-half of the bulk of the blood, and, therefore, allowing for the small quantity dissolved by the liquor-sanguinis, we find that they absorb thirty-nine per cent., or thirteen times as much oxygen as water could. That this oxygen is combined in, and not merely dissolved by, the corpuscles, is indicated by the fact observed by Bernard, that pyrogallic acid, a substance that combines eagerly with free oxygen, when it is injected into the veins, will pass out of the body of the animal without undergoing oxidation. It has, therefore, been generally assumed, although upon imperfect proof, that the colouring matter of the corpuscles was capable of combining with oxygen in the lungs, and afterwards of giving that oxygen out again—in small doses, as it were—to the substances to be oxidized. This notion has been recently raised to the dignity of a theory by some beautiful experiments which physiology owes to a physicist—Professor Stokes, of Cambridge. Stokes's researches appear hardly to have received from physiologists the attention they deserve, and I, therefore, venture to present a brief description of them here. Hoppe-Seyler had previously recorded the curious fact, that when a ray of white light passes through a weak solution of blood, and is afterwards decom-

* Bernard, "Liquides de l'Organisme," i. 460.

posed by a prism, two dark bands make their appearance in the green portion of the spectrum. Stokes repeated and verified the fact, and it soon became in his hands the starting-point of a new train of research.

He treated a solution of blood-corpuscles with an alkaline reducing agent, and observed that its colour almost instantly changed from scarlet to purple-red, the hue of veinous blood. On examining the spectrum, he now found that the two dark lines had disappeared, and that a single line, intermediate in position between them, had become visible. On shaking the tube with air, the scarlet colour and the two lines at once returned, but, after a few minutes, again disappeared; and this could be repeated many times. Hence it was evident that the scarlet arterial blood lost its oxygen to the reducing agent, and subsequently recovered it again, when shaken, from the air. The fact is so important that I prefer to give it in Stokes's own words. He says,—

"The colouring matter of blood, like indigo, is capable of existing in two states of oxidation, distinguishable by a difference of colour, and a fundamental difference in the action on the spectrum. It may be made to pass from the more to the less oxidized state, by the action of suitable reducing agents, and recovers its oxygen by absorption from the air."*

Hoppe-Seyler had shown that this colouring matter is different from the so-called *hæmatin*, which is obtainable by artificial means from the blood, and Dr. Sharpey therefore suggested that the true colouring matter should be named *cruorine*. The name is a good one, and does not, like "hæmato-globulin," which is adopted by Hoppe-Seyler, involve any hypothesis. In the oxidized—the scarlet state—it is distinguished as *scarlet cruorine*, and in the reduced state as *purple cruorine*. It is hardly necessary to point out how intelligible an explanation these facts afford of the oxygen-carrying power of the blood-corpuscles. In the lungs the purple cruorine of veinous blood takes up oxygen, and becomes scarlet cruorine; and in the whole of the general circulation, but more particularly in the capillaries, oxidation is effected by means of this oxygen, and the cruorine, to a great extent, passes back to the purple state. Hoppe-Seyler has since found that the blood of a rabbit which has been killed by drowning exhibits the spectrum of purple cruorine. In ordinary states, however, even veinous blood retains enough unreduced cruorine to give the two-line spectrum.

But Stokes has discovered another fact which is of extreme importance in regard to the question of animal oxidation. He

* "Proceedings of the Royal Society," vol. xiii. 357.

found that a solution of the blood-corpuscles from arterial blood—a solution, that is, consisting mainly of scarlet cruorine—when excluded from the air, slowly *reduced itself*, and showed, after a time, the purple colour and the one-line spectrum of purple cruorine. On opening the tube and shaking it with air the scarlet colour returned, and with it the two-line spectrum. Hence it is clear that scarlet cruorine is capable of oxidizing a portion either of its own substance or else of the serum, from which it is impossible wholly to free it in the experiment. Whichever it be, it certainly is a part of the blood itself which is oxidized by the cruorine; and this fact is, as we shall presently see, in perfect accord with the theory to which we are led by other considerations.

These curious optical experiments, apart from their physiological interest, have already yielded some practical results of considerable importance. Soon after the publication of Stokes's memoir, Mr. H. C. Sorby contrived an ingenious adaptation of the spectroscope to the microscope, and by its means succeeded not only in repeating all Stokes's experiments, but also in furnishing medical jurisprudence with a new and most valuable means of identifying blood-stains. The spectrum-microscope has since but somewhat improved in construction, and many readers of this journal have no doubt seen it, and the beautiful experiments which its inventor performs with it at some one of the recent scientific *soirées*. It is described in detail in a paper by Mr. Sorby, read before the Royal Society, April 11, 1867. A scrap of blood-stained fabric, 1-10th of an inch square, containing possibly not more than 1-1000th of a grain of colouring matter, may be experimented upon by its means, and the most certain evidence of the nature of the colour obtained. It has already been found useful in criminal trials.

Another interesting application of the spectroscopic examination of blood was made by Hoppe-Seyler. Claude Bernard discovered, some years ago, that the poisonous action of carbonic oxide gas was due to the circumstance that it had the power of displacing all the loosely-combined oxygen from the corpuscles, and of occupying its place in a somewhat more stable form of combination. All blood, veinous as well as arterial, after treatment with carbonic oxide, acquires a uniform red tint, which it retains with singular persistency, being, in fact, as Bernard expressed it, *mineralized* by the gas. Hoppe-Seyler submitted some of the blood so treated to optical examination, and found that it gave a spectrum very similar to, but not identical with, that of scarlet cruorine. But when excluded from the air, instead of reducing itself like scarlet cruorine does, it remained unchanged for an indefinite period

of time. Hence the process indicated a delicate and certain test for use in cases of suspected poisoning by carbonic oxide. I myself, in ignorance of Hoppe-Seyler's experiments, made the same observations. I have by me now a sealed tube, which has for more than a year contained a solution of blood through which carbonic oxide had been passed. The spectrum has not altered in the slightest degree.*

To return from this digression, it is clear that we are now acquainted with the mode in which oxidation is effected in the body, as far as the earlier stages go. Oxygen is absorbed in the lungs, combines with the cruorine, and is afterwards given out again. But at this point we are compelled to pause to consider two more complex and exceedingly important questions. These are, firstly, What is oxidized? and, secondly, Where is the oxidation effected? Liebig, as everybody knows, divided the substances oxidized in the body into two great classes, corresponding with the chief constituents of food. These were the non-nitrogenous, or "respiratory" elements, and the nitrogenous, albuminous, or "plastic" elements. The former embraced fat, sugar, starch, etc., and all its members were supposed by him to be oxidized in the blood, and to evolve no force but heat as the result of their combustion. The latter consisted of the organized tissues, and in particular the muscular tissue, the oxidation of which chiefly resulted in the production of mechanical work. It is an obvious corollary from this hypothesis, that the oxidation of a solid tissue must be effected in the tissue itself, outside the walls of the capillaries, and we are therefore compelled to believe in two distinct modes of oxidation. Substances in the blood are in direct contact with the corpuscles, and may therefore be supposed to unite directly with the oxygen of the scarlet cruorine; whereas, for the direct oxidation of a tissue, it is necessary to assume that some of the oxygen leaves the corpuscles, traverses the walls of the blood-vessels, and arrives at the comparatively distant fibres in a state of solution, but in an uncombined condition. In its extreme form, Liebig's hypothesis has long been known to be untenable, for it cannot be doubted that nitrogenous substances, as well as non-nitrogenous ones, are oxidized in the blood, and contribute to the animal heat; and

* I believe reduced cruorine to be the most delicate, as it certainly is one of the simplest, qualitative tests for oxygen known. If a weak solution of blood is inverted in a test tube over mercury, it reduces itself in a day or two, and a small prism will then show the one-line spectrum. The minutest trace of oxygen will now restore the original spectrum; a single drop of distilled water will often contain enough. I obtained incidentally in the above experiments a confirmation of the previously known fact, that carbonic oxide is disengaged during the absorption of oxygen by potassic pyrogallate. Air from which the oxygen had been removed by this re-agent, when added to reduced cruorine, caused the latter to give a two-line spectrum, which lasted for weeks.

it has recently been demonstrated by the conjoined efforts of Traube, Heidenhain, and Donders, and still more distinctly by Fick and Wislicenus, Frankland and Parkes, that the oxidation of nitrogenous substances cannot account for nearly all the work done in the body. Traube, indeed, has started a rival hypothesis, which has been accepted by Fick and Wislicenus in their celebrated memoir;* namely, that the oxidation of muscle contributes nothing whatever to muscular power, but that the whole of the latter is derived from the oxidation of non-nitrogenous bodies, such as fats and the so-called hydrates of carbon. But as they agree with Liebig in placing the seat of this oxidation in the tissue, there is no great difference, as far as the blood is concerned, between the two views.

But are there, indeed, two distinct kinds of oxidation going on in the body, one inside and one outside the walls of the blood-vessels? Is it probable, or indeed possible, that sufficient oxygen can pass out through the thin walls of the capillaries to account for the enormous force exerted by the body in twenty-four hours? Mayer thought not, and argued against the notion in his immortal treatise, "Organic Motion in its connection with Change of Matter," published more than twenty years ago.† I believe he was right in this, as in so many other things, and I have elsewhere‡ drawn attention to his arguments, and endeavoured to add others to them. The question is one of immense theoretical and practical importance, and I will therefore enter into it in some detail.

To begin with, it is necessary to bear in mind another well-known and most important function of the blood. All the tissues of the body, the muscles among the number, are subject to a ceaseless process of disintegration and destruction. The elementary parts of which a tissue consists, have a definite term of life. They are born, grow, decay, and die, having previously developed new germinal matter from which their successors arise. There is no doubt about this, and it is equally certain that the nutrient matter, the *pabulum*, from which the new parts are formed and nourished, is derived from the blood, some portion of which must travel through the thin walls of the capillaries, and irrigate the tissue. Extreme uncertainty exists as to the mode in which this exudation takes place. At first sight it would appear to be simply a question of liquid diffusion; but, apart from the colloidal nature of the albuminous bodies of the blood, there are some striking points of difference between the composition of the blood and that of

* "On the Origin of Muscular Power," "Phil. Mag.," June, 1866 (Supplement).

† "Die Organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel." Heilbronn, 1845.

‡ "Phil. Mag.," May, 1867.

the muscular juice, in respect even of some of the most diffusible substances. Thus common salt, an extremely diffusible compound, is found in large quantity in the blood, but is almost entirely absent in muscular juice, and the blood is invariably and necessarily alkaline; whereas the liquid of the tissue is acid, and may even contain, as Liebig has remarked, enough acid to neutralize the blood. Probably the pressure under which the blood flows, influences in some manner the exudation, but it would be vain to pretend that it explains it.*

The excess of the nutrient fluid, together with the products of the disintegration of the tissues, returns to the blood, a portion perhaps direct to the capillaries, but the great bulk, in all probability, through the lymphatics, which seem to act as overflow-pipes to the tissues. Mayer therefore suggested that the quantity of lymph might be taken as a measure of the quantity of fluid exuded in a given time. Bidder and Schmidt estimate the lymph returned to the blood in twenty-four hours at 22 lbs., but it is safer to assume it to be at least 30 lbs. It would hardly do, however, to take even this quantity as a representation of the average exudation through the capillary walls in twenty-four hours, and I have thought it right to treble it, so as to have a decided over-statement of its probable quantity. We thus get 90 lbs. a day, or about 40 litres. Now if oxygen leaves the blood and passes into the tissues, it is evident that it must pass in solution in this 40 litres of exudate. How much oxygen could possibly be dissolved by this 40 litres? There is every reason to believe that the exudate does not differ materially from liquor-sanguinis in composition, and we have before seen that liquor-sanguinis is about equal to water in its power of dissolving oxygen. 40 litres of water would dissolve less than two grammes of oxygen; and this quantity of oxygen, whether it were employed in the oxidation of muscle, of fat, or of sugar, could not yield as much as 3000 metre-kilogrammes† of force. But it may be urged that, though unlikely, it is still possible that the exuding fluid may be able to carry with it a larger proportion of oxygen than this. Be it so. Let us make the absurd assumption that every hundred volumes of exudate contains more oxygen than the arterial corpuscles themselves do, when saturated with the gas. If each hundred volumes of exudate contained forty volumes of oxygen, 40 litres would still only contain about 23 grammes, and this, in uniting with oxidizable

* Some of these arguments were suggested to me by Dr. Marcet, F.R.S., who has studied the bearings of dialysis on pathology with great care and success.

† A metre-kilogramme is the force required to raise one kilogramme one metre. It is equal to about 7¼ foot-pounds, and is now almost universally employed as the measure of force.

materials, could only yield about 30,000 metre-kilogrammes of force.

Now the daily work of the heart alone is estimated by Donders at 86,000 metre-kilogrammes, and it is an extreme under-statement to assert that the total daily work of the body in health is 100,000 metre-kilogrammes. To do even this quantity of work, twice the quantity, or 200,000 metre-kilogrammes of force must, as Heidenhain has proved, be provided; so that even taking the highest possible calculation of the quantity of oxygen which could pass into the tissues, we see that it cannot account for one-sixth of the work done in them. It is more probable, indeed, that it cannot account for one-sixtieth. To supply the minimum force per diem exerted in the body, there must be a daily exudation of about

264 litres, or ¼-ton, if the exudate contains as much oxygen as arterial corpuscles; or,
3500 litres, or 3¼-tons, on the more probable supposition that it will not dissolve more than water will.

These figures appears to me to furnish a complete answer to the current theory of tissue-oxidation, and to force us inevitably to the conclusion so clearly pointed out by Mayer, namely, that the whole, or nearly the whole, of the animal oxidation, is effected in the blood itself, and consequently that there must exist some provision by which chemical force set free inside a capillary is converted into mechanical work in the tissues outside of it.

This view of the nature of animal oxidation tends to define more clearly our knowledge of the functions of the blood. Nutrition is one of its functions. It carries with it in its course the appropriate *pabulum* for the repair of all the tissues of the body. Bones, nerves, glands, and muscles, all alike reproduce their elementary parts at the expense of material derived from its fertilizing stream. And as these elementary parts attain their term of life they decompose and liquefy, passing again into the blood, for the most part through the same lymphatic vessels which take back the excess of the nutritive fluid. In the lymphatic vessels and glands much of the lymph is once more organized into blood, but the products of the disintegration of tissue are probably incapable of this renewal, and, in the absence of evidence must be supposed to return into the blood in an unorganized condition.

Equally important with the foregoing is the function of oxidation, to which the force as well as the heat of the body is due. Nitrogenous as well as non-nitrogenous bodies are oxidized in the blood, and though we do not yet know the precise conditions or the precise mode in which the oxidation

is effected, we are justified in inferring that it is by the direct agency of the corpuscles. There is on this view no ground for the assumption that either force or heat is due exclusively to the oxidation of one or the other class of organic compounds. Both are oxidized, and one is as likely as the other to be the motive power. Even the muscle itself, inasmuch as it is finally oxidized in the blood, may give rise to muscular work, and we must therefore conclude that Traube's hypothesis is as much an over-statement on the one side as Liebig's was on the other.

The changes effected by the blood in the exercise of its functions are subject, to a most remarkable extent, to the control of the nerves; and little as we know of this the most obscure region of physiology, we cannot avoid the conclusion that they are directly concerned in the transformation of chemical force into mechanical effect. The muscular currents of electricity, which have been so carefully studied by Du Bois-Reymond, Helmholtz, Heidenhain, and many others, are, no doubt, closely connected with this conversion; but I will abstain from speculations which are apt to degenerate into bare guesses. Dim foreshadowings of great discoveries lie before us, and it is better, after clearly stating to ourselves the truths already established, or made probable, to wait with humility, watching till diligent and patient search shall have been rewarded with fresh unveilings. If we can clear a point or two in the intricate forest of knowledge which lies before us, we shall have done truer work than by any amount of speculation.

THE LUNAR CLEFTS—MARE VAPORUM—JUPITER'S SATELLITES—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

In our last paper we followed the Great Cleft as far as the crater *Hyginus:* we now proceed to give the results of the observations of B. and M. upon its future course; referring at the same time to the diagram in our last number. This crater, 3¾ miles in diam., and tolerably deep, with 6° or 7° of brightness, has its ring split by the cleft, which passes across the interior, with elevated edges, in such a manner that the continuity of its banks is nowhere interrupted. Of this they had an interesting proof upon one occasion in the waning moon, when the steady air admitted of a power of 300: the interior of the crater was wholly in shade, with the exception of two minute but very brilliant lines of light in the position of the cleft, while the wall on the N.E. and W., where the cleft encountered it, was interrupted by a very narrow but perfectly black shadow. From the E. side of *Hyginus* issues an extremely small cleft, 4 or 5 miles in length, which was detected by Lohrmann, and seen, once only, by B. and M. After leaving this spot, the cleft, in its westward course, touches on five extremely small craters, or possibly only "longish circular widenings," and is bordered on the S. by two broad flat hills; all these being objects of an exceedingly difficult character. Beyond the tenth crater the cleft becomes wider, flatter, and less regular, and ends as it began, at a long hill, at whose S.W. extremity a little crater (*Agrippa* b) is faintly perceptible. Its whole length is about 106 miles, its average breadth nearly 1 mile: the steeper are the more reflective parts; the light of the flatter ends losing itself in that of the surrounding surface. With the great achromatic at Dorpat, M. subsequently found that a great part of this cleft consisted of a chain of confluent roundish cavities. The plain S. of the cleft contains a few small craters of various sizes, two small dark spots and one larger, and one of a green hue, about 3° in brightness, and extending over about 3,600 square miles. On the N. the cleft is attended by a number of very low parallel chains of hills; one mass immediately N. of *Hyginus* shows a curious spiral arrangement; but generally they point S.W. or S.S.W., and this bearing is visible over a considerable area in this direction, overspread with minute banks and ridges, invisible excepting near the terminator, and usually only from 40 to 60 yards in height. Our authorities especially direct attention to the fact that in this region, where no deception can be

occasioned by foreshortening, the general parallelism of all chains of hills and lines of valleys is peculiarly evident: this bearing—"geognostically" towards 10h. (of a dial divided into 24h.) is visible throughout the *Apennines*, the *Hæmus*, the *M. Vaporum* and its neighbourhood, *Ukert*, *Pallas*, *Bode* (28), *Julius Cæsar*, *Agrippa*, *Godin*, *Dionysius*, and in part the *M. Tranquillitatis* itself: in many parts it exceeds any other direction as 30: 1, and between Mt. *Hæmus* and the cleft of *Ariadæus*, it is almost the exclusive one. They point out also another peculiarity, the great variety of local shading, or "colour," in this region under varied illumination. In Full Moon the higher of the ridges N. of *Hyginus* come out with a reflective power of 4° or 5°, the interjacent valleys, with 3° or 3½°, brighter than the levels of the *M. Vaporum*, and the darkest part of the neighbourhood does not lie here, but at the foot of some higher mountains E. of the cleft; and even these are less dark than the spot *Boscovich*. On the other hand, about the time of the quadratures, a large blackish somewhat undefined spot comes out just between the two higher chains of mountains near *Hyginus* γ (the two N. of that crater in our diagram) covering these ridges, whose summits are with difficulty visible in it, and contrasting singularly with the surrounding landscape. It is evident, on inspection, as B. and M. remark, that it cannot be shadow; nor can it be merely a feebler illumination, which could not in this way reduce to blackness the yellow, yellowish grey, and pale greenish hues of the lunar surface; so that we have here a colour variable with the phases, which appears to require some further explanation than merely varied reflection. The day and night are also the summer and winter of the moon; and consequently a change of colour whose period is that of a lunation may as well be the result of temperature as of light; and a careful examination of such regions seems especially suited to lead to some discoveries as to the physical economy of our neighbour-world. Had this been Schr's. conclusion, it would have been entirely in character with his general ideas, but proceeding from observers so little disposed to receive any evidence of change, it is worthy of pointed attention. Fortunately the district is one very well marked, easily found, and unaffected in appearance by libration.

The second great cleft, that of *Ariadæus*, lies W. of the preceding, and is described by B. and M. the reverse way—from W. to E. It was discovered by Schr., like the other, which it exceeds in length, breadth, and probably depth, though less easy to find on account of its more mountainous surroundings. It begins at a mountain *Ariadæus* γ (see the diagram), and after a course of about 18 miles, receives another

cleft coming from the S., 16 miles long, very narrow, and of inferior depth—a difficult object detected by B. and M. 23m. further, it strikes on the mountain *Ariadæus* β, without, however, perceptibly dividing it, as it had done a small ridge a little previously. On the other side of β it recommences in the same direction, and passes through two minute craters, appearing here to be very deep. 14m. further on, it is interrupted by the mountain *Ariadæus a*, till its traces are next recovered in a narrow ravine among the hills, in a somewhat altered direction. Henceforward it splits every elevation, great and small, in its way, although a high ridge, Silberschlag *a*, so compresses it that the separation can only be perceived with difficulty. Further on, the heights on either side are flatter, and it terminates in a small crater S. of *Boscovich*, after a course, windings included, of 143 miles. Gruithuisen observed a very minute prolongation of it, between *Arago* A and *Ritter*, for a considerable distance towards the equator. This, though confirmed by Kunowsky, was not made out by B. and M., but has since been seen by Kinau and Schmidt. If it is really a continuation of the great cleft, it may possess considerable selenological interest, as showing how much more effect the same cause has produced on a comparatively mountainous surface than on a depressed plain. Two other very minute clefts (if not three) between *Sosigenes* and *Arago*, and two more S. of *Sabine* (which had been seen by Lohrmann) belong to the *M. Tranquillitatis*. Schmidt has detected several others along this shore.

S.E. of *Hyginus*, and on the edge of the *M. Vaporum*, lies the crater *Triesnecker*, encompassed by a narrow equable wall, 14 miles in diameter, and 5400 feet high on the E. On every side but the E. it is encompassed by long clefts, forming the most numerous group known to B. and M., some of which had been seen by G. β and γ, the most distinct, form an angular junction near the wall: the whole could very seldom be seen at the same time. δ is interrupted by a low ridge. Between β and γ is a very difficult little crater. Though the connection and branching out of these clefts appeared to B. and M. unique on the moon, yet the similarity to a terrestrial river-system is very slight: there is no winding, or widening in either direction, and the interruption by a hill must negative any such idea.

Having thus given an abstract of B. and M.'s description of this curious region, we may find it worth while to compare it with the results obtained by other observers. First of all, the original discoverer, Schr., has given a long description, and a figure of the two principal clefts, which alone he saw, and two additional diagrams of the W. one. The name *Hyginus*

was applied by him to the whole dark hill-country N. of the small crater now so called: and his first cleft commences there as a flat valley: he did not notice any of the minuter craters in its course, but places upon it, as interrupting it, the *Hyginus* of B. and M., of which he remarks, in a subsequent observation with the 27 f. reflector, that it has certainly no ring: at the same time he found that the W. end of the cleft, which he had previously carried right up to the wall of *Agrippa*, is lost about one diameter of that crater N. of it. The second cleft he brings, not out of B. and M.'s small crater, which he does not notice, but from a point further E., the end of his *Hyginus;* and originally drew it as dividing a flat bright crater (his D), about half as large as *Agrippa*, which has on its S.W. side a smaller crater, q, and another flat, crater-like depression ν, between q and the cleft. Of these objects q is the *Silberschlag* of B. and M., but D and ν cannot be identified in their Map; the ridges, however, about their *a*, N.E. of *Silberschlag*, and those N. of that crater, in some states of illumination assume a ring-like aspect: a source of deception well known to lunar observers. Schr. also shows the crater which B. and M. place on the N. bank of the cleft; but in two separate designs he has made the cleft pass further S., about equidistant between this lesser crater and *Silberschlag*. From all this it will be seen how difficult it is to reconcile representations by different hands, or even to account for their discrepancy. Further W. Schr. places two mountains in the course of the cleft; the first of these, σ, seems to be the *a* of B. and M.; the second, μ, is their β. What struck him greatly was, that he saw, 1794, Mar. 8, with a 7 f. Newtonian, the ring of his D on both sides, and the mountains σ and μ, all split by the cleft: Sept. 1, with his 27 f. reflector he found the ring of D and the mountain μ undivided (agreeing in this last with B. and M.). 1796, Feb. 15, μ was divided, with a four-inch Dollond: Mar. 15, with his 13 f. reflector, D had its ring incomplete and open on the N.E., where the cleft enters it; but the other side of the ring (namely, the very narrow gorge at *a*, B. and M.) was undivided, as well as the mountains σ and μ: 1798, July 19, he and Olbers, with the 13 f., both saw μ undivided, and the latter noticed the slight bend in the cleft shown by B and M. a little W. of this spot. Schr. also found at the S. end of the chain of which μ is the central portion, a mountain which he had never seen before, though the highest of all, casting a long spire of shadow while the rest had none, and measuring 3200 f. From this he was induced to infer former atmospheric obscuration; and he could not resist a very cautious suggestion, that the singular alternately open and closed aspect of the mountains above the cleft might point to some artificial

operation in utilizing a natural feature. The alteration is much more probably due in part to libration, exposing to the eye more or less, at different times, of a very narrow line of shade, and partly to the change of seasons on the moon, which, slight as it is, is sufficient, by varying a little the bearing of the sunrise, to cause the same edge of a cleft running E. and W. to be at one time illuminated, at another in shade.

We will now turn to Lohrmann, and hear what he has to say—premising that the date of his "Sections," though earlier, did not differ much from that of B. and M. And here again we find discrepancy enough to be unpleasant. His first cleft, to begin with, is much more sharply bent at *Hyginus* than in our diagram: and though he agrees with B. and M. as to the wider commencement, and the four craters in its course before reaching *Hyginus*, yet it is remarkable, that while he makes the first and fourth very minute, he enlarges the two intermediate ones to two-thirds of the size of *Hyginus*, saying also in his text that there are two larger and two smaller deep cavities, which under favourable circumstances he has several times distinctly seen. One of these little craters, he adds, lies on the edge of *Hyginus*; his drawing shows that it is additional to the other four. He remarks that *Hyginus* has no visible ring, and has drawn none round the two larger of the four craters. Another minute crater is drawn, but not described, just W. of *Hyginus*. He carries the end of the cleft as far as the site of B. and M.'s *Agrippa* b, stopping it against a chain of hills running up to the wall of the great crater.

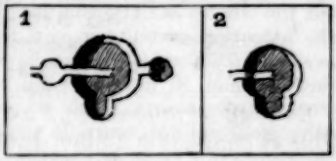
The cleft of *Ariadæus* he begins (from E.) with a small crater, as B. and M., and has shown their two minute pits on either side of it, further W. He recognizes Schr.'s D as a flat crater, the ring of which is a mere bank on the N.: he shows traces of ν, and like Schr. places the smaller crater opposite *Silberschlag* at some little distance from the N. bank. After several failures he found the mountain measured by Schr. He carries the cleft through everything in its course, expanding it a little at its W. end. It is less luminous, he says, than that of *Hyginus*, but still visible in Full. Of the cleft-system near Triesnecker he perceived nothing. Chacornac perfectly recognizes Schr.'s D and ν, and makes the cleft divide a, but not β, W. of *Silberschlag*. Schmidt has added considerably to the number of clefts in this district; but as the descriptions in his catalogue are very brief, and without designs, they are little more than memoranda, which will become fully intelligible, we trust, hereafter, by comparison with his promised lunar map.

As the present is our best opportunity of studying these

curious objects, I shall beg permission to add a few observations of my own; they are indeed of a very fragmentary character, but may perhaps be useful to those who are disposed to make out the whole detail of this interesting region, which, after all the attention given to it, is still but imperfectly known. My excellent $5\frac{1}{2}$ in. object-glass carried me, of course, considerably further than B. and M., and my $9\frac{1}{2}$ in. "With" speculum, would have made a much greater advance, but for the long continuance of unfavourable weather.

Beginning, as at first, at the widened extremity of the *Hyginus* cleft, where it lies like a long pool under a bank of some height on the left-hand, I find that in the middle of this part it sends out a narrow continuation towards the E., which having cut through a low dark mass of hills, is soon lost in the plain on the other side of them; beyond this, at a short distance, its direction is carried on by the N. edge of a mountain mass, but I could not trace any cleft there. Less than half-way from this "pool" to *Hyginus*, an insulated hill stands close above it on the right, after passing which it becomes convex towards the W., and evidently broader, contracting, however, suddenly, and turning more to the left a little way before reaching *Hyginus*. In this broader part, it would seem that the three first craters of B. and M. must be placed (including the two which L. has so exaggerated in size), and I might have detected them at this time in steadier air. *Hyginus* itself I have repeatedly seen without a wall, though possibly it might come out close to the terminator, where I have never observed it. Schm. doubts whether any actually ringless craters exist on the moon, but they are known on the earth, the "explosion-craters" of Humboldt; cavities surrounded by inconsiderable margins of ejected fragments only; such are the Maars of the Eifel, and several in Auvergne and Java. I have never seen the two bright lines crossing the floor, as described by B. and M. Once I detected one of them, corresponding with the S. edge of the cleft, very narrow, but obvious, and cut off by a narrow black space from the E. slope of the crater; but I have more frequently seen the whole cleft entering the crater as a broader line of light. On one occasion, an indistinct uncertain shading led me to suspect that its level was somewhat depressed as it passed through the crater's edge, and I have never been able to trace it beyond $\frac{2}{3}$ the breadth of the floor, nor to ascertain how this white stripe comes to an end, though once I thought there was a slight shadow there. The two accompanying sketches, taken (1) 1861, April 18; (2) 1867, Feb. 7, will give some idea, though a very rough one, of the object. They show also the cavity which encroaches on the N. edge of *Hyginus*, and which has been given, though too small, by L.,

but omitted by B. and M.; it is about $\frac{1}{7}$ the diameter of the larger crater. The projecting cusp on the right-hand was on the latter occasion very luminous. The two small craters E. and W. of *Hyginus* are larger than as shown in L. or B. and M.: when sketched, the one was all bright, the other partially in shade. The bending of the cleft does not take place in *Hyginus*, as shown by L., but in or near the latter crater. I have no note of any other crater W. of *Hyginus*, but I carry the cleft further than B. and M., turning it, like L., with a bend more S. towards the site of *Agrippa* b, and then again bending it W. and carrying it on as a very minute line across the N. slope of *Agrippa*, at a considerable distance from the ring. B. and M. may have seen part of this as the long bank shown (but a little too far N.) in our diagram.



The second great cleft I have seen bordered in all its length, though less distinctly in the portion E. of *Silberschlag*, by a narrow faint shadow parallel to it on the S., as though on that side at least it had an elevated margin.* I have drawn it as commencing on the N. side of *Ariadæus a*. Three times it has appeared to me interrupted by the narrow ridge W. of *β*, which it divides in B. and M. I have never seen *β* nor *a* divided by it; as to *a* on the other (E.) side of *Silberschlag*, I am less confident. I may have mistaken it for the ridge N. a little W. of *Silberschlag*, by which, like Schr., I have seen the cleft entirely intercepted. It has not appeared to me to pass close to the crater opposite *Silberschlag* as in B. and M., but at a little distance, as in Schr. and L., and the bend at this place is greatly exaggerated by B. and M. The semi-crater form of Schr.'s D I have plainly made out. A little E. of this spot it sends off a very distinct branch to the S.E., which apparently forms a communication with the W. end of the *Hyginus* cleft, somewhat N. of the point where the latter carries on a branch, already noticed, across the N. slope of *Agrippa*. I have no note of the small crater at the E. end of this cleft, but I have remarked a very faint narrow dark line continued on from near that spot still further E., towards the end of the *Hyginus* cleft.

These minutiæ may be of some interest as showing the multiplicity and intricacy of these cracks, and as aids to further study; but the most curious remains to be specified. 1861, April 17, I perceived that the part of the cleft between *a* and *β*

* With the great Northumberland Telescope, at Cambridge, aperture 11½ in., Breen has seen both banks very plainly, alike in valley and mountain, and has noticed them stretching a short distance into the dark part of the disc.

is double, or rather that in this space are comprised the ends of two clefts not in the same line, but running parallel for a short distance, as is shown in the accompanying very rough sketch. The S. portion, though narrow, was very evident. As I have found this subsequently confirmed, I would venture to propose an addition to the nomenclature here, and to call the E. portion "the cleft of *Silberschlag*," as the W. is that of *Ariadæus*. How so apparent a feature should have escaped all previous observers, and even Schmidt himself, it is not easy to understand; but it proves how much yet remains to be done for the topography of the Moon.

This becomes still more evident with great apertures and high powers, for which many peculiarities here are doubtless reserved. Such was especially my conviction in the use of Mr. Bird's noble 12 in. silvered mirror, 1865, Sept. 5. The illumination was then far too high, but some idea of the scene may be obtained from the fact that the bottom of the first cleft W. of *Hyginus* was distinctly seen as a grey streak bordered by two parallel bright lines. This was interesting in another respect. The steep banks, as less directly enlightened, should have had a darker appearance, on optical grounds, than the included level space; their opposite aspect must have been due to local colour. On one occasion I thought, in using my 9½ in. mirror, that the *Silberschlag* cleft passed *over*, not *through*, a considerable mountain; but the observation was too hasty, and should be repeated.

As to the region of *Triesnecker*, I have noted several additions. The angular point of meeting, and the minute crater on the slope beneath it, are both set too near the ring by B. and M., and that angle is really the common junction of four clefts; one of which proceeds due S., I know not whether it may be ζ, ill-drawn in their map, or a line of communication with it; another runs as a continuation of β up to the N.W. edge of the great ring: the cleft γ, as Breen had previously found, is double, with overlapping ends, like those of the junction between *Ariadæus* and *Silberschlag*; and possibly this may be found to be a peculiarity of frequent occurrence. γ appears, too, to lead directly towards the small crater near its N. end: while c, or ϵ (both which letters are affixed in the map to the cleft pointing to the centre of *Triesnecker*—ϵ has been accidentally misplaced in our diagram), probably passes W. of the little crater E. of *Hyginus*.

We leave now this curious region with the sincere hope that some of our readers may be induced to make it an object of patient research: a very little experience will show that no

hasty investigation can possibly master its difficulties: many of the clefts are extremely minute, and the shadows, by which alone they can be detected, are in proportion fugitive, so as to require watching, literally, almost from hour to hour, in order to trace their continuation and connection. It would be well, too, to check our results in the opposite illumination, though the large clefts, at least, are not so distinct in the waning moon.

A little way out of our diagram to the N. lies the fine crater *Manilius* (24) 25 miles in diameter: the broad and peak- and crater-besprinkled ring of which attains in general a luminosity of 8°, and so becomes always a conspicuous object; it may be perceived even in the lunar night, and was one of H's pseudo-volcanoes. The E. side attains 7700, the W. 7500f. (Schr. found 7500 E., 8000 to 9900 W., and the W. wall 2200f. above the plain).

Between *Manilius* and *Menelaus* (15), Schr. has represented a very dark spot of an oval form, to which he gave the name *Boscovich*. L., though he represents it, seems not to have thought it worthy of a name, and has transferred the appellation, without notice (a most unusual procedure with *him*), to another dark spot half-way between it and *Agrippa*, where it has been recognized by B. and M., and is shown in our diagram. From Mr. Birt's observations it seems that B. and M. have failed in delineating this region (the *old* site); Schr. and L. seem to be nearer the present state of the surface, but the dark tone given by Schr. seems either to be visible only under certain circumstances, or to have subsequently faded. In these districts the flat ring-form so common elsewhere, is supplanted by openings, or intermissions among the parallel ridges universally prevalent here, so that two of their sides only are bordered by a rampart. Of this kind is *Julius Cæsar*, a large steel-grey depression, of only 1° in reflective power at the N. end, becoming as bright as 3° southwards. In its peculiar aspect Chacornac traces the effect of a retreating tidal wave, which he thinks may have penetrated it from the neighbouring sea; and he considers this as one of the many evidences of similar action. Several dark valleys unite it with a similar, but much smaller and not quite so dark, formation at some distance N. On its W. side the true crater *Sosigenes*, 14m. broad, and, according to Schr., 3700f. deep, intervenes between it and the *M. Tranquillitatis*: at a little distance E. is the *Boscovich* of L., and B. and M., another very dark spot of the same kind.

JUPITER'S SATELLITES.

As the planet Jupiter is now conspicuous, though not so high as desirable, the following particulars of his system will

be interesting. Sept. 6th. I. in transit, 7h. 56m. to 10h. 16m., its shadow 8h. 14m. to 10h. 34m. II. ditto, 8h. 26m. to 11h. 18m., its shadow 9h. 2m. to 11h. 54m.—13th. I. in transit, 9h. 40m. to 12h., its shadow 10h. 9m. to 12h. 28m. II. ditto, 10h. 43m. to 13h. 35m., its shadow 11h. 39m. to 14h. 32m. (These two will be beautiful spectacles.)—20th. I. in transit, 11h. 25m. to 13h. 45m., its shadow enters 12h. 4m. II. enters 13h. 2m.—22nd. I. leaves disc 8h. 11m., its shadow 8h. 52m.—29th. I. in transit, 7h. 38m. to 9h. 57m. its shadow 8h. 27m. to 10h. 47m.

OCCULTATIONS.

Sept. 7th. B.A.C. 6292, 6 mag. 9h. 49m. to 10h. 22m.—8th. ρ^2 Sagittarii, 5½ mag., 9h. 47m. to 10h. 51m.

THE FOOD OF THE SALMON.

BY W. HOUGHTON, M.A., F.L.S.

Difference of opinion has long prevailed with regard to what constitutes the food of the salmon. As I have lately been examining a large number of the stomachs of this fish, it may interest the readers of this magazine to hear the conclusion at which I have arrived. But let us first of all see what authors have said on this question. The earliest mention of the food of the salmon with which I am acquainted, occurs in Gesner's work "De Aquatilibus," p. 828. Quoting Hector Boëthius, he says, "On what food the salmon lives, or whether it lives on any at all, is as yet a doubtful question, since, when disembowelled, the stomach shows nothing but a certain thick fluid." Gesner then adds, "I myself also, whenever I have examined a dissected specimen, have never found anything in the stomach and intestines except a yellowish mucus and particles of white grit.* Our fishermen affirm that they never find anything in the stomachs of the large fish, but only in those of the smaller ones; for the larger ones which are known by the name of salmon, live on nothing but water, preferring that which is thick and muddy as being more nutritious. But I have heard from an old and experienced fisherman that the fish, until it is a true salmon, feeds on aquatic lice, but that after spawning it will eat any fish that happens to come in its way; the fisherman said he had frequently found fish in their insides." Shaw

* "Album lapillum." I suspect he means by these words the masses of calcareous crystals so frequently found in the intestines of salmon.

says, "All fishermen agree that they never find any food in the stomach of this fish. Perhaps during the spawning time they may entirely neglect their food, as the Phocæ, called sea-lions and sea-bears, are known to do for months together during the breeding season, and it may be that like those animals, the salmon returns to sea lank and lean, and comes from it in good condition. It is evident that at times their food is both fish and worms, for the angler uses both with good success, as well as a large gaudy fly, which the fish probably mistakes for a gay libellula, or dragon fly" ("Gen. Zool." v. Part I., p. 42). The preposterous idea that any fish can subsist without ever taking food was maintained by Daniel, who stoutly argued that the salmon lived on nothing but water! Dr. Knox states that from the time the salmon enters the fresh water it ceases to feed, properly speaking, although it may occasionally rise to a fly, or be tempted to attack a worm or a minnow, in accordance seemingly with its original habits as a smolt. But after first descending to the ocean and tasting its marine food, it never again resorts to its infantile food as a constant mode of nourishment. This great fact, he continues, well understood by fishermen and anglers, has been placed by Mr. Young, of Invershaw, beyond all doubt. Nothing is ever found in the stomach and intestines of the fresh sea salmon but a little reddish substance, which Dr. Knox, after a careful microscopic examination, concluded to be the ova of some species of Echinodermata. Of the salmon, therefore, while in the sea, he maintains this to be the sole and constant food.

M. Valenciennes describes the salmon as voracious, and states that its food consists of fishes (*Ammodytes Tobianus*), but Dr. Knox asserts that there exists not a single fact in the history of British salmon to support this opinion. He refers to various fanciful theories suggested by fishermen and others in regard to the marine food of the salmon, and concludes by stating that in spring, as the spawn fish are descending with the smolts, they may occasionally be tempted with an artificial fly or lob-worm, but as to their feeding regularly in rivers, Mr. Young's experiments have negatived the assumption beyond all doubt.

Dr. Knox is here partly right and partly wrong; he is right in saying that the fresh-water salmon seldom or ever feeds, but unquestionably wrong in maintaining so positively that other fish never constitute the salmon's food in the sea. The same writer thought that the excellent quality of the salmon as an article of food is to be traced to the rich eggs of the Echinodermata, which he considered to be its principal food.

Mr. Yarrell writes as follows—"That the salmon is a voracious feeder may be safely inferred from the degree of perfection in the arrangement of the teeth, and from its known habits, as well as from the well-known habits of the species most closely allied to it; yet of the many observers who have examined the stomach of the salmon to ascertain the exact nature of that food which must constitute their principal support, few have been able to satisfy themselves."* Faber says that "the common salmon feeds on small fishes, and various small marine animals." Dr. Fleming, as quoted by Yarrell, remarks that their favourite food in the sea is the sand eel, and Yarrell says he has himself taken the remains of sand-launce from the stomach. That herrings enter largely into the list of the food of the salmon while in the sea, I can state from personal observation. The salmon in whose stomachs I frequently found one, two, three, or even four herrings together, were from the coast of Norway. Some of the herrings were nine or ten inches long. I never found any other kind of food. This, however, will do no more than prove that salmon feed greedily enough on herrings, and not that other fish do not form part of their diet. There is an abundance of herrings off the coast of Norway, and probably they were more readily captured by the salmon than other fish, during the months of May, June, and July, at which time I made my examinations.

With respect to the river or fresh-water salmon, I never detected the smallest trace of food of any sort either in the stomach or intestines; and Mr. Bowring, a most respectable fishmonger at Wellington, obligingly examined for me a great number of stomachs. We neither of us ever found any food in them, nothing but a thick white or yellow mucus with the gritty particles already noticed, and some intestinal worms, amongst which tape-worms were the most common. But it is asserted by many that the idea of a salmon abstaining from food the whole time the fish is an occupant of fresh water, is a physiological heresy; that so active a fish *must eat* in order to maintain itself and supply muscular force; and that the very fact that salmon are taken with minnow, worm, or fly, is a convincing proof that they *do feed* in fresh water; that the vacuous condition of the stomach is readily accounted for by the well-known habit this fish has, in common with many others, of emptying its stomach when hooked or netted, by an instinctive act of fear, or to facilitate its escape by lightening its load. That the salmon does occasionally throw up the contents of its stomach is probable enough, and has indeed been witnessed. "I was

* See "British Fishes," ii. p. 52.

on the sea in a boat," writes Mr. Campbell, "rowing, one bright, calm day, along some rocks near the mouth of a salmon river, when I espied one of the poaching nets used by the Highlanders. . . . . We went towards the net, and in so doing started a salmon, which dashed into it. I saw the salmon strike and entangle itself, and in a moment begin to vomit a number of herring-fry. I could see them quite distinctly, for we were exactly over the fish. I pulled up the net as fast as I could, and in a second the salmon was in the boat. So quick was I, that there were upwards of a dozen of the fry still in his mouth, although he had been ejecting a shower of them as I drew him to the surface. Of course there was nothing in his stomach; but the idea of saying that salmon do not eat is ridiculous. I have myself caught scores with a worm, and thousands are so taken every year, which sufficiently proves that they eat; but when they find themselves fast on a hook or in a net, they disgorge, like the Solan goose, or as the salmon did that I have just described, and thus nothing is found in their stomachs when they are opened."*

Another way of accounting for the absence of food in the salmon's stomach is by its extraordinary digestive properties. "The rapid growth of the fish seems to imply that its digestion must be rapid, and may perhaps account for there never being food in its stomach when found."†

Let us examine these various arguments.

1. *The salmon vomits up his food when hooked or netted, consequently he has nothing in his stomach.* Granted that he does sometimes, does it follow that he always does so? Or if he always did so, can he vomit up the indigestible portions from the intestines? For it must be remembered that the whole intestinal tract in river-salmon, as a rule, never shows evidence of food. But since herrings and other fish are frequently found in the stomachs of sea-salmon, it is evident that the vomiting theory must fall to the ground. If they invariably eject the food from their stomachs in fresh water, why do they not invariably do so in salt?

2. *The rapid digestion will account for the absence of food in the stomach.* But if river-salmon feed, as asserted, there must be times at which the fish is caught immediately after having swallowed some food; for though the digestion may be rapid, it cannot be instantaneous. Besides, the digestion theory will not account for the absence of all indications of food in the intestine.

3. *The fact that salmon are frequently taken with a worm, minnow, or fly, is a proof that the fish do feed whilst in the*

* "Life in Normandy," pp. 36 and 37. Ed. 1865.
† "Harvest of the Sea," p. 192.

fresh water. I do not pretend to say that a fresh-water salmon never by any chance takes a particle of food, but that its doing so is so rare as merely to prove by its exception the generality of the rule. It must also be remembered that some fish will occasionally take a tempting bait more for sport than for food. A pike, when absolutely gorged with food, will not unfrequently seize a bait in his mouth, and yet refuse to swallow it, as trollers who use a gorge-bait well know. What does an artificial salmon-fly resemble in nature? Certainly no kind of winged insect, not even a gaudy *libellula* or *agrion* either in form or motion, for no libellula ever swims in the water, least of all after the fashion in which the artificial fly is made to locomote by the angler. Some have thought, among whom is Sir Humphrey Davy, "that the rising of salmon and sea-trout at these bright flies, as soon as they come from the sea into rivers might depend upon a sort of imperfect memory of their early smolt habits." But it is more probable the salmon takes the glittering fly—which is allowed to sink a little in the water—for a fish, for fish forms his principal food when an inhabitant of the sea. But be this as it may, the undoubted fact that the stomachs and intestines of fresh-water salmon are almost invariably found empty is a convincing proof, for reasons adduced above, that this fish abstains from food during its sojourn in fresh water.

4. With respect to the physiological paradox as to how an animal can live without taking food, it must be borne in mind in the first place, that, notwithstanding the voracity of the carnivorous fishes, and their extraordinary digestive capabilities, they are able to exist for long periods of time without food. Gold and silver fish may be kept for months without perceptible food, and certainly as we descend the scale of creation we shall find instances of long-continued abstinence more frequently. Snails in conchological cabinets have been known to live for years without a particle of food or drink. Frogs and toads will unquestionably exist for years immured in wood and stone in positions which entirely forbid the introduction of any kind of food.

But there must be a limit to this power of existing without food. A salmon, if he was never to eat, would undoubtedly die. But how, it will be asked, can muscular force be maintained for so many months without food? There can be no other explanation than this, that the salmon lives on his own abundant fat, stores of which are laid up throughout the whole body of the fish, but especially in the abdominal regions. This supply of fat was deposited during the time the salmon was an inhabitant of the sea, and when, as I have said above, he is a voracious feeder. Now we know, notwithstanding the

assertion of old Izaak Walton* to the contrary, that the longer a salmon continues in fresh water the more does his flesh deteriorate. Mr. Alexander Russel, a good authority on salmon, is quite right when he says that "salmon taken in or near the sea are the best for food." Let any one compare the difference in the quality of the flesh between a sea-salmon and one that has long been a sojourner in fresh water. He will notice in the sea-salmon the abdomen to be soft and tremulous with abundance of fat, that of the river-fish firm and comparatively destitute of fat. And this continued abstinence from food is, no doubt, in some measure the reason of the fish's gradual deterioration till the exhausting process of spawning renders the salmon now altogether unfit for food. The salmon's abode, therefore, in fresh water should be regarded as a quasi-hybernation, during which life is maintained upon stores already laid up in the organism. That muscular force may be maintained, and in fact that it is chiefly kept up by the combustion, not of the nitrogenous elements, but of the carbonaceous, has been rendered tolerably certain, and the circumstance that a salmon may move about for a long time in fresh water without supplies of food beyond his own abundant fat, is not actually much more than a further instance of what takes place in hybernating animals, as the bear, which goes fat into winter quarters and comes out very thin. The same may be said with regard to experiments that have been made, showing that the Swiss mountains may be ascended solely upon the strength afforded by butter and other non-nitrogenous food.

According to the researches of Dr. John Davy, "the gastric juice, and probably the other fluids concerned in the function of digestion in fishes, are not secreted till the secreting organs are stimulated by the presence of food—a conclusion in harmony with a pretty general physiological law, and in accordance with what has been best ascertained respecting the gastric juice in other animals." Dr. Davy infers the following corollary from the above, "that the migratory species of salmon, such as the salmon and sea-trout, which attain their growth, and become in high condition in the sea, there abundantly feeding and accumulating adipose matter, though not always abstaining in fresh water, which they enter chiefly for the purpose of breeding, are at least capable of long abstinence there without materially suffering."† He suggests the probability of this being owing to none of their secretions or

* Walton's words are:—"It is observed that the further they get from the sea, they be both fatter and better."

† "Physiological Researches," p. 168.

excretions, with the exception of the milt of the male and the roe of the female being of an exhausting kind.

The conclusion, then, at which I think we may safely arrive with regard to the food of the salmon is—that it feeds freely in the sea, and chiefly on other kinds of fish, such as sand-launces, herrings, and other *clupeidæ*, though other animals, such as shrimps, and various crustacea occasionally form part of its diet; that during its sojourn in the sea the salmon lays up a store of adipose matter; that it very seldom feeds during its abode in the fresh-water rivers, but lives on the supplies of its own internal fat; that though for some time the flesh does not perceptibly deteriorate, it is rendered poorer in quality towards the end of its sojourn in the fresh water, both from the exhaustion of its own supplies of fat and from the effects of spawning; that it rapidly improves when it has reached the salt water, when it again lays up a fresh supply of adipose matter, which will support it during its sojourn in the rivers.

A SYNOPSIS OF THE RECENT BRITISH OSTRACODA.

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(*With Two Plate.*)

Of the various orders included in the great tribe Entomostraca, there is, perhaps, not one more generally interesting than that of which we propose to treat in the present paper. When we consider the great abundance and wide dispersion of the Ostracoda through the fresh waters and seas of our own period, and the countless myriads in which the shells of ante-diluvian species have come down to us, embedded in strata of varied character and age—for example, Silurian, Liassic, Carboniferous, Permian, Tertiary, and Post-tertiary—it will be evident that the geologist and palæontologist must, to a very large extent, share their interest in this group with the student of recent zoology and physiology. It will be seen also that any light which may be thrown upon the structure and habits of living forms must likewise be of great importance to the student of extinct species, as tending to exhibit more clearly their natural affinities, and to establish sounder principles of classification than can be attained by the study merely of the external covering of the animal, which only is left to us in the case of fossil examples. The prodigious numbers in which the fossilized carapaces of these creatures sometimes occur, is

almost incomprehensible, some strata of certain rock formations seeming to be almost entirely composed of them. Amongst the recent species I know of no case analogous to this, except that of the dwellers in salt marshes and estuary mud; and I have no doubt that, were the mud-banks of our tidal rivers, and the swamps adjacent, suddenly petrified, we should, in many cases, find that the resulting stratified rock would exhibit as wonderful a concourse of once-living crustacean shells, as those which have just been spoken of. Mr. W. K. Parker has indeed conjectured, from a study of their fossil Rhizopoda, that the post-tertiary clays of the district round Peterborough constitute a littoral, brackish water-deposit; and it is remarkable that the Foraminifera there found, agree, to a very large extent, with those which I have myself taken in the salt marshes of our north-eastern coast. In strata much older than the post-tertiary, one would not, of course, expect to find species exactly identical with those now living. In washings of these clays, however, with which Mr. Parker has kindly supplied me, I have not been able to detect any shells of Ostracoda; it is, indeed, noticeable, that fossiliferous strata which are rich in Foraminifera are mostly poor in Ostracoda, and *vice versa*. Such, on consideration, one would naturally expect to be often the case. In all the salt marshes which I have had the opportunity of examining, living Ostracoda have been very abundant. If the net be passed carefully along the surface of the soft mud, so as to take up a thin layer, and the mass thus obtained be then washed through the net sufficiently to clear it of the fine ooze which will be found to constitute the greater part of its bulk, the residue will mostly consist of Ostracoda, living and dead, grains of sand, fragments of decaying vegetable matter, and very probably a good many living Foraminifera. This will mostly be the result wherever the water is brackish, and deposits a good deal of slimy mud, but in fresh water, or at the mouths of rivers, where the stream is clear and rapid, and does not produce much fine deposit, the Ostracoda, and other Microzoa, will be found much less plentifully. My belief is, therefore, that those strata which exhibit such very abundant and closely-packed remains of the smaller Cypridæ and Cytheridæ have most likely been formed in shallow, brackish lagoons, or at the mouths and deltas of rivers. The species of Ostracoda which I have found in these situations are, *Cytheridea torosa* (Jones), *Cythere pellucida* Baird, and *Loxoconcha elliptica* Brady; while in water, a little further from the saline influence, but still slightly partaking of it, it is not uncommon to meet with *Cypris salina* Brady, and *Cypridopsis aculeata* (Lilljeborg), as well as Entomostraca belonging to other orders. Some

crustacea of larger type are also commonly met with in brackish waters,* *e.g.*, *Corophium longicorne*, *Palæmon varians*, *Mysis vulgaris*, the common shrimp, etc.; but these, not having a hard, durable, calcareous investment, are not found in the fossil state. The Foraminifera which I have usually found in company with the Ostracoda above mentioned are, *Polystomella striatopunctata*, *Quinqueloculina agglutinans*, *Trochammina inflata*, *Rotalia Beccarii*, and *Nonionina depressula*; the relative abundance of these forms varying with the locality.† The marshes of the Northumberland and Durham coasts are the only ones which have yet been carefully examined, and it is quite probable that other districts might yield different species.

By far the greater number of Ostracoda at present known have been described from fossil specimens, and the generic and specific characters have, of course, been taken almost exclusively from the external characters of the shell, the chief of these being, its general form and contour, mode of hingement, arrangement of lucid (or muscle) spots and style of surface ornament. The general structure of the animals themselves has indeed been known sufficiently to form good grounds of separation between some well-defined families, such as Cypridæ, Cytheridæ, and Cypridinidæ, but the more minute anatomy indicative of generic and specific differences has, until recently, been very little understood or investigated. The family Cytheridæ, for instance, has been considered by most authors as consisting of some three or four genera (or sub-genera of Cythere), separated from each other by shell-characters merely, and the family Cypridæ of two genera. But when we consider that, of the one hundred and thirty-seven species of Ostracoda now known as living in the waters of Great Britain, all except ten belong to these two families, and that amongst fossil species the disproportion is even greater, it is evident that, amongst so vast a number of species, many important differences of internal structure must exist, and that these stood in need only of careful investigation in order to form good grounds of generic subdivision. Accordingly, we find that much has of late years been done in this direction, more especially by Zenker and Fischer in Germany and Russia, and by Lilljeborg and G. O. Sars in Scandinavia. The researches

* See my paper on "Salt Marshes and their Inhabitants," in INTELLECTUAL OBSERVER, Vol. v. p. 26.

† Any readers of the INTELLECTUAL OBSERVER living in the neighbourhood of salt marshes or muddy estuaries would materially contribute to the knowledge of a very important and interesting branch of natural history by collecting the Microzoa in the manner above described. The best material for collecting-nets is "crinoline;" the things captured may be preserved, either by drying, or by immersion in dilute spirit. I should myself be very glad of the opportunity of examining any such collections, and would with pleasure name the specimens obtained.

of the last-named author, embodied in his recent work on the marine Ostracoda of Norway,* are of particular interest to English naturalists, seeing that the marine faunas of the two countries exhibit a very close affinity. He has succeeded, after a most careful and painstaking investigation of the Norwegian species, in accurately ascertaining the minute structure of animals belonging to all the described fossil genera (excepting only, as he says, *Cytheridea*, which, however, I regard as belonging to the same genus as the forms he describes under the name *Cyprideis*), and has also established a large number of new species and genera. After a similar survey of the British marine and fresh-water species (in which I have received most valuable assistance from many collectors and naturalists whom I need not here stop to name), I have myself added many species to the list, and have found it needful also to propose some few new genera. A brief analysis of these I propose now to lay before the reader; but before doing so, it will be desirable to describe succinctly the general type of structure of the Ostracoda.

Each member of the class Crustacea is considered, typically, to be divisible into twenty-one annular segments, or somites, seven of which belong to the head (*cephalon*), seven to the thorax (*pereion*), and seven to the abdomen (*pleon*). But it is only in very few cases, and these amongst the more highly organized members of the class, that these segments, or their rudiments, are discernible. In most cases some of the segments are fused together, so that their real nature is to be recognized only by the presence of certain limbs or appendages which indicate their existence. Thus, under the hard, calcareous carapace, or shield, which protects the head and back of the lobster, we find gathered all the cephalic and thoracic members of the animal, and so we learn that the great dorsal buckler consists, in fact, of all the cephalic and thoracic segments of the body, cemented into one strong protecting plate. This principle, infinitely modified, runs through the whole class; but we also find that, in addition to the coalescence of various segments, other segments are often entirely absent, their presence not even indicated by the existence of any limbs or appendages. So that it is only by the careful study and comparison of the whole group that the real nature and homologies of any particular organ can be made out. The appendages of the twenty-one segments of the typical Crustacea may be tabulated as follows:—1, Eyes; 2, 3, First and second antennæ; 4, Mandibles; 5, 6, Two pairs of jaws; 7, 8, 9, Foot-jaws; 10—14, Ambulatory legs; 15—20, False or abdominal feet; 21, Tail-piece or post-abdomen. In the

* "Oversigt af Norges Marine Ostracoder" af G. O. Sars, 1865.

Ostracoda the segments of the body are almost entirely obsolete, the body itself being soft, and entirely covered by two usually hard and calcareous, but sometimes thin and horny, valves.

The family Cypridæ, which includes almost all the fresh-water, and a few of the marine Ostracoda, may be taken as the basis of our description. The various organs will be better understood by reference to the plates, where they are figured in detail.

The first limb, or *upper antenna* (Fig. 1, *b*), here consists of a tapering seven-jointed curved appendage, which bears at its apex a dense bundle of long plumose setæ. The second, or *lower antenna* (Fig. 1, *c*), is usually stouter, four-jointed, strongly bent or "geniculate," clawed at the extremity, and adapted for walking, though in many cases it is also provided with a lash of setæ, which adapts it likewise for swimming. The *mandible* (Fig. 1, *d*) consists of an elongated triangular body, the base of which is directed downwards, and is divided into numerous teeth. From one side springs a four-jointed palp (Fig. 1, *f*), whose basal joint bears one of the branchial organs (Fig. 1, *e*). Of the two pairs of jaws, the *first* (*g*) is the larger, and is divided into four segments; to it is attached a large branchial plate (*h*), the principal breathing organ of the animal. The *second* pair (*i*) is small, and has a non-articulate palp, which, in the male, is often modified into a prehensile organ. In some genera this pair of jaws bears also a small branchial plate. There are *two pairs of feet*, the first (*j*) clawed at the extremity, and adapted for walking; the last (*k*) slender, flexuous, and always tucked up within the shell. The *post-abdomen* (*m*) consists of two flattened elongated rami, which are very movable, strongly clawed at the extremity, and lie side by side, mostly within the shell. There are sometimes two eyes (*a*), but these are mostly confluent. The *ovaries* (*o*) lie round the body of the animal, directly beneath the shell. The *copulative organs* of the male are of very curious and complex structure, and have mostly attached to them a *mucous gland* (Fig. 4), consisting of a double central cylinder, and several whorls of radiating filaments. The shell is thin and fragile, and mostly somewhat reniform or ovate in shape, devoid of sculpture, except sometimes a fine impressed punctation; occasionally densely hispid or even spinous.

We shall now briefly point out the characters in which the other families chiefly differ from the Cypridæ.

Cytheridæ.—This family includes by far the greater number of the marine Ostracoda, and some few species are inhabitants of fresh water. Both pairs of antennæ (Fig. 2, *b*, *c*) are en-

tirely destitute of the filamentous brushes which give swimming power to many of the members of the preceding family; but the upper antennæ (*b*) are beset with strong marginal spines or setæ; and the lower (*c*) are provided with a single long tubular flagellum, which communicates with a poison-gland (*v*), situated in the anterior portion of the body of the animal. There is only one pair of jaws (*g*), similar to the first pair of the Cypridæ. Three pairs of feet (*r*, *s*, *t*), all of which protrude from the shell, are very similar in form, though increasing in length from the first to the last, and are adapted for walking. The post-abdomen is composed of two very small and inconspicuous lobes (*m*). The ovaries are not produced between the two valves. The male copulative organs are exceedingly large, and of complex structure, and are not provided with a "mucous gland." The shell is mostly more or less quadrangular in outline, but sometimes ovate or subtriangular; very variable both in structure and in external ornamentation.

Cypridinidæ.—The antennæ are here exceedingly large and muscular, the upper pair (Fig. 10, *b*) often bearing very long and slender terminal setæ, as well as a densely-tufted auditory seta. The lower (*c*) is especially powerful, composed of an excessively large and muscular basal joint, to which is attached a nine-jointed branch, bearing numerous plumose setæ, which constitute it a powerful swimming apparatus. The mandible proper is rudimentary, but its palp (*f*) is developed into a large prehensile limb. Three pairs of maxillæ, of very variable structure (*g*, *h*, *i*). One pair of feet, of very peculiar structure (*k*), forming a long, flexuous, annulated, vermiform process, bearing several toothed spines at its extremity and evidently homologous with the second pair of feet of the Cypridæ. The post-abdomen is composed of two large closely-appressed plates (*m*), which are powerfully clawed along the posterior margin. Eyes two (*a*), pedunculated. Shell subovate or subspherical, having a distinct beak, with a large underlying notch in front, through which the antennæ are protruded whilst swimming.

Some of the members of this family have very slight swimming power, and live chiefly amongst mud; others are very agile swimmers, and are often taken in the towing-net—more especially at night—near the surface of the sea. They seem, indeed, to contribute very materially to the production of the wonderful phosphorescence of the tropical seas.

Conchoeciadæ.—Closely allied to the preceding family. The upper antennæ are, however, in the female, very small; the lower antennæ almost exactly as in Cypridina. Mandibles distinct, narrow, and toothed; palp large and pediform, terminating in long claws. Two pairs of jaws. Two pairs of feet,

the anterior long, five-jointed, and dissimilar in the male and female; posterior very small and rudimentary. Post-abdomen consisting of two short, clawed laminæ. Shell excessively thin and flexible, almost membranaceous; in general shape approaching that of the Cypridinidæ.

Polycopidæ.—Both pairs of antennæ natatory: the upper simple; the lower two-branched. Mandibular palp small, not pediform. Two pairs of feet: the anterior natatory; the posterior branchial. Abdomen terminating in two short unguiferous laminæ. Eyes and heart wanting. Intestine forming a simple sac. Shell thin, calcareous, not notched.

Cytherellidæ.—Antennæ very large; the upper multiarticulate and geniculate; the lower broad, two-branched, much like the feet of the Copepoda. Mandibles very small, bearing a large setose palp. Three pairs of legs, which are scarcely pediform: the anterior two branchial; the posterior rudimentary. Abdomen terminating in two very small and narrow spiniferous laminæ. Ova and young borne under the shell of the female. Valves very unequal in size, not notched; structure very dense, hinge formed by a simple groove.

It is impossible, in the necessarily restricted limits of a magazine article, to give a detailed account of the specific characters of all the British Ostracoda. I propose, however, to indicate briefly the more important characters of the different genera (a thing which has not yet been done with reference to anatomical characters in this country), giving under each genus a list of the British species belonging to it, and appending such remarks concerning them as may appear likely to be of general interest, or helpful to those seeking for special information respecting this interesting group of Microzoa.

Family—Cypridæ.

Genus Cypris, Müller.—Upper and lower antennæ both provided with a tuft of plumose filaments, the lower pediform. Both pairs of jaws bearing branchial appendages. Second pair of jaws in the male prehensile; in the female consisting of a short lobe, a palp which terminates in three setæ, and a small branchial plate with six radiating respiratory setæ. Post-abdominal rami long and slender, having two terminal curved claws and a small seta. Males provided with a "mucous gland," composed of a double cylinder beset with radiating filaments. Shell mostly subreniform or ovate, and of no great thickness. Inhabits fresh water.

British Species.—*C. fusca*, Straus; *incongruens*, Ramdohr;

virens (Jurine), *obliqua*, Brady;* *elliptica*, Baird; *punctillata*, Norman; *bispinosa*, Lucas; *gibbosa*, Baird; *tessellata*, Fischer; *clavata*, Baird; *salina*, Brady; *gibba*, Ramdohr; *trigonella*, Brady; *reptans* (Baird); *serrata* (Norman), *compressa*, Baird; *striolata*, Brady; *ovum* (Jurine), *lævis*, Müller; *cinerea*, Brady; *Joanna*, Baird.

Most of the species of the genus Cypris, being enabled to swim freely by means of the setose appendages of the antennæ, are active in their habits, and very abundant in ponds and small pieces of water, especially where there is much decomposing vegetable matter. They do not appear to be so numerous in large clear lakes, and from elevated mountain tarns they are frequently altogether absent. Some species, however, have their lower antennæ very sparingly armed with setæ, and those so short and few as to give little or no swimming power. Species possessing such characters (*C. reptans* and *serrata*) have been placed by authors in the genus Candona; but it seems best to restrict that genus, as will be presently mentioned. There is considerable diversity in the colour and external appearance of the Cyprides: some being perfectly smooth; others simply punctate or striated; others densely hairy; while one species (*tessellata*) is most beautifully reticulated with a pattern which has much the appearance, in fine examples, of silver filagree work. The prevailing colours are uniform shades of brown and green; but some species, as *salina* and *serrata*, are variegated with dark markings upon a light ground. Four of the species mentioned above (*elliptica*, *gibbosa*, *clavata*, *Joanna*) have not been found, or at any rate have not been recognized, since their publication by Dr. Baird; and one, the finest of all (*bispinosa*), is claimed as British only on account of its occurrence in the island of Guernsey. It was originally found in Algiers. Perhaps the most abnormal species is *C. gibba*—an animal which, though its antennæ seem well adapted for swimming, apparently never uses them for that purpose, but contents itself with an inactive life upon clayey bottoms, with which its colour closely assimilates. Its shell is much more dense than is usual in this genus, and may perhaps need more power to sustain it in the water than the antennæ are able to afford.

Cypridopsis, nov. gen.—Like Cypris, except that the post-abdominal rami (Fig. 3) are quite rudimentary, consisting of two slender, setiform processes, springing from a common base. Lives in fresh water.

C. vidua (Müller), *aculeata* (Lilljeborg), *villosa* (Jurine).—

* The species to which my own name is attached, are quoted chiefly from a "Monograph of the Recent British Ostracoda," read before the Linnæan Society, and which will be published in the Transactions of that body.

All small species. The first-named is of common occurrence; colour whitish, marked with two broad and conspicuous transverse bands of black. The other two are somewhat rare; colour green. *C. aculeata* affects chiefly water that is slightly brackish, and in such situations is sometimes accompanied by *Cypris salina*. From the green colour of the animal, and the contents of the digestive canal, it would appear that it feeds upon the vegetation among which it is found, and not upon animal matter, as seems to be the case with most crustacea.

Paracypris, G. O. Sars.—Upper antennæ seven-jointed, shortly setose; lower antennæ bearing, on the last joint but one, a pear-shaped, pedicillated hyaline vesicle. Second pair of jaws having a branchial appendage. Second pair of feet like the first in form and size, pediform, five-jointed. Post-abdominal rami large, clawed. Shell much higher in front than behind. Habitat, marine.

P. polita, G. O. Sars.—A very handsome species living in water of considerable depth, and apparently of rare occurrence in our seas, though ranging from the Channel Islands to Shetland and Norway. The remarkable vesicle attached to the lower antennæ is visible also in Pontocypris; its use is entirely unknown.

Notodromas, Lilljeborg.—Antennæ like those of Cypris, upper seven, lower six-jointed. Second pair of jaws without a branchial appendage, pediform in the male. Post-abdominal rami long and rather slender. Mucous gland and copulative organs of the male very complex in structure. Shell of very different shape in the male and female. Inhabiting fresh water.

N. monachus (Müller).—A tolerably common species, often occurring in great abundance and at once recognizable by its peculiarly quadrate form, flattened ventral surface and deep black colour.

Candona, Baird.—Like Cypris, except that the lower antennæ possess no tuft of setæ and that the second pair of jaws is destitute of a branchial appendage. Inhabits fresh water.

C. albicans, Brady; *lactea*, Baird; *compressa* (Koch); *candida* (Müller); *detecta* (Müller).—These animals are unable to swim, and are altogether sluggish in their movements, mostly living on the muddy bottoms of ponds and stagnant water. They are all whitish in colour, the shell surface polished, finely punctated, or (as in *C. compressa*) delicately reticulated.

Pontocypris, G. O. Sars.—Lower antenna bearing a vesicle, as in Paracypris. Mandible and first pair of jaws having a branchial appendage; second pair of jaws without branchia, palp large and subpediform, three-jointed, the last joint in the

female armed with two long claws. Last pair of feet four-jointed, flexuous, terminating in several long setæ, the margin of one of which (Fig. 5) is beautifully pectinated. Post-abdominal rami (Fig. 6) well developed. Shell thin, higher in front than behind, covered, more or less, with fine appressed hairs. Marine.

P. mytiloides (Norman); *acupunctata*, Brady; *trigonella*, G. O. Sars; *angusta*, Brady.—These animals, of which the first-named is by far the most common, seem to delight in a muddy bottom; their movements are far from active, and they have not much capacity for swimming. *P. mytiloides* often occurs pretty plentifully in the mud of sheltered, quiet bays, and I have found it very abundantly amongst the ooze from oyster-barrels.

Bairdia, M'Coy.—The anatomical structure of this genus is as yet very imperfectly known, but is most probably nearly similar to that of the following genus. It differs, however, in having the post-abdominal rami very large and well developed. The valves are very unequal in size, the left being much the larger and overlapping the right both on the dorsal and ventral surfaces; outline subrhomboidal.

B. inflata (Norman); *acanthigera*, Brady; *obtusata*, G. O. Sars; *complanata*, Brady.—The first-named species is very closely allied to *B. subdeltoidea*, a form first described from fossil specimens, but having a very wide range at the present day, extending over the Atlantic and Indian Oceans and into the Mediterranean. In the British seas its place is taken by *B. inflata*, which has not yet been observed in any other region. I possess specimens of *B. subdeltoidea* dredged off Guernsey, but these have every appearance of being fossilized.

Macrocypris, nov. gen.—Antennæ short and robust, the upper seven-jointed and shortly setiferous, the lower five-jointed and armed with long apical claws. First pair of jaws having an unusually small, subovate, branchial plate; second pair destitute of any branchial appendage; palp, in the female, large and subpediform, in the male, very robust and clawed. First and second pairs of feet very different in structure, the first pediform and strongly clawed, the second entirely covered by the shell. Post-abdominal rami rudimentary. The male possessing a long and narrow mucous gland. Shell elongated, attenuated at the extremities, smooth and polished; right valve larger than the left and overlapping on the dorsal margin.

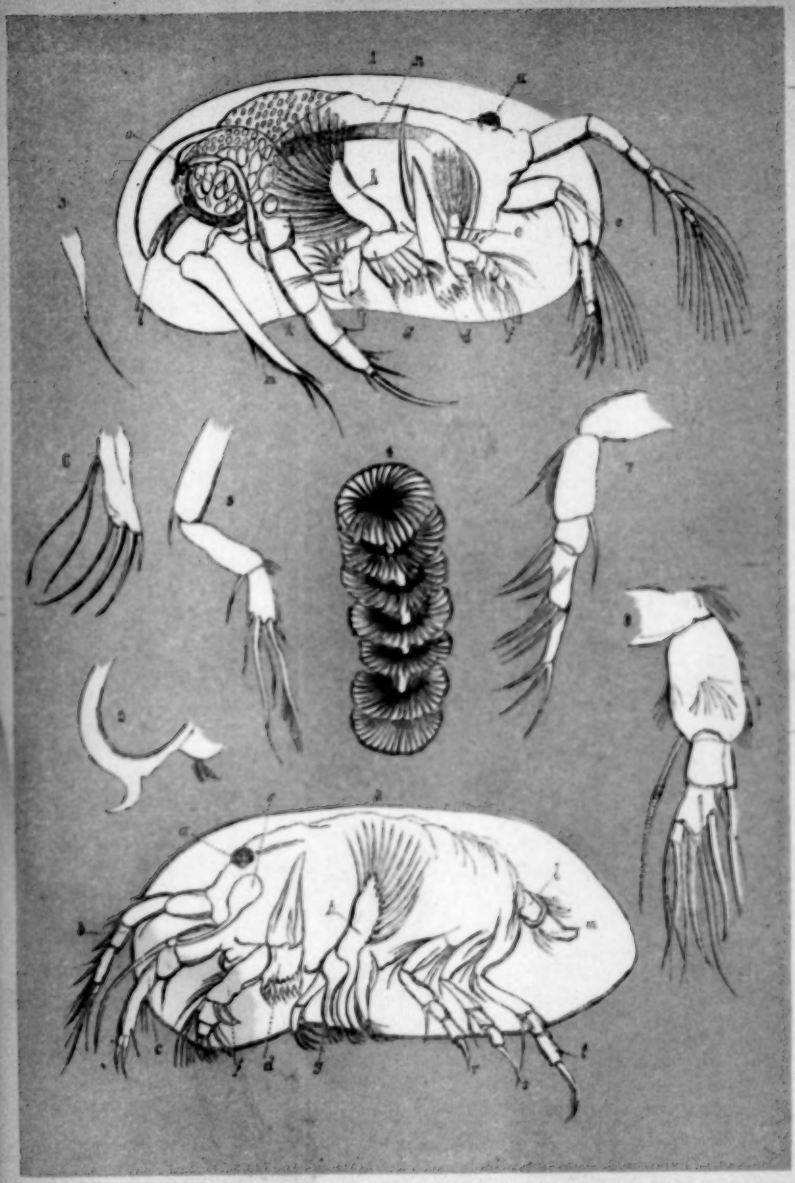
M. Minna (Baird).—This fine species is very rare in Britain, having been found only off the coast of Shetland, but in the Norwegian seas it appears to be more common. It is referred by Sars to the genus Bairdia, that author not having seen any

living specimens belonging to the typical form of Bairdia. I have myself found, however, that the animal (and also the shell) of *B. inflata*, which certainly belongs to M'Coy's genus, differs in some important respects from *M. Minna*; it therefore becomes necessary to propose another generic name for this species.

Family—Cytheridæ.

Cythere, Müller.—Upper antennæ robust, five or six-jointed, armed on the anterior margin with three long curved spines, mostly one on the third and two on the fourth joint; lower four-jointed; mandibular palp three or four-jointed, bearing in place of branchial plate, a tuft of from two to five setæ. Eyes, one or two. Valves unequal, mostly thick and strong; surface variously ornamented with simple papillæ, tubercles, fine impressed punctations, or even with prominent ridges and spines or deep fossæ. Outline, as seen from the side, mostly subreniform or quadrangular. Hinge joint formed by interlocking teeth, two on the right and one or two on the left valve, with sometimes an intervening bar and furrow. Marine.

C. lutea, Müller; *viridis*, Müller; *pellucida*, Baird; *badia*, Norman; *tenera*, Brady; *oblonga*, Brady; *rubida*, Brady; *albomaculata*, Baird; *convexa*, Baird; *cuneiformis*, Brady; *limicola* (Norman); *globulifera*, Brady; *tuberculata* (G. O. Sars); *concinna*, Jones; *angulata* (G. O. Sars); *dubia*, Brady; *Finmarchica* (G. O. Sars); *villosa* (G. O. Sars); *Jeffreysii*, Brady; *laticarina*, Brady; *marginata*, Norman; *quadridentata*, Baird; *emaciata*, Brady; *mirabilis*, M.S.; *mucronata* (G. O. Sars); *Dunelmensis* (Norman); *Whiteii* (Baird); *antiquata* (Baird); *Jonesii* (Baird); *acerosa*, Brady; *semipunctata*, Brady. —The thirty-one species here included under the genus Cythere are distributed by G. O. Sars and other authors between the two genera Cythere and Cythereis. Considered with reference to mere shell-characters no tenable line of separation can be found, but Sars supposed that he had discovered, in some minute but constant differences of animal structure, peculiarities which sufficed to place the generic distinction on a satisfactory basis. These characters were chiefly that in the restricted genus Cythere the flagellum of the lower antenna was equally long in both male and female; the mandibular palp three-jointed, and armed with simple curved setæ; while in Cythereis the flagellum of the female was very much shorter than in the male, the mandibular palp four-jointed and bearing three stout curved and pectinated setæ. These distinctions, though perhaps of no great importance, might have been allowed to form sufficient ground for the division of a large and somewhat incoherent genus,



Anatomy of Cypridæ and Cytheridæ.

Anatomy of Cyprinoids.

but it happens that some species which are common enough in the British seas, though unknown to Sars when his memoir was written, are exactly intermediate in character, presenting different combinations of those peculiarities which were relied on to separate Cythere from Cythereis. It is therefore necessary either to constitute two or three new genera for the reception of these aberrant forms, or to give a more extended signification to the original genus, so as to include all under the one term Cythere. The latter is the course which I have adopted. The intermediate species here referred to are *C. albomaculata, convexa,* and *rubida. C. convexa* exhibits a remarkable approach to the genus Bairdia in general outline, the two valves being very unequal and decidedly beaked behind. In all essential points, however, it is a true Cythere. This genus includes a very large proportion of the fossil species; its preponderance appears, indeed, to have been greater during the earlier periods of the earth's history than now, though possibly this may partly arise from the great thickness and durability of the shells of many species, and especially of many of the fossil forms which have thus been preserved, while other more fragile species may have been destroyed.

The Cytheres have no power of swimming, and are met with abundantly both amongst the fuci of the littoral zone and amongst the mud and sand of the deep-sea bed. A muslin or crinoline net used amongst the rock-pools of any part of our coast cannot fail in the summer months to capture numbers of them. In these situations *C. albomaculata, lutea, viridis,* and *villosa* are perhaps the commonest; while beyond the littoral zone we most frequently meet with *pellucida, tuberculata, lutea,* etc. The forms here named *acerosa* and *semipunctata* seem to be very rare. Their anatomy is not at all known, but their external peculiarities lead to the belief that they may constitute the types of new genera.

Limnocythere, nov. gen.—Animal like Cythere, except that the upper antennæ (Fig. 7) are armed with short setæ instead of spines. They are five-jointed, slender, the antepenultimate joint excessively short, terminal joint much elongated. Shell rather thin, irregularly tuberculate or spinous. Inhabits fresh water.

L. inopinata (Baird); *monstrifica* (Norman).—I have not yet been able completely to examine the structure of these animals, but the conformation of the upper antennæ seems at once to separate them from the foregoing genus. They are very minute, and from their mode of life on clayey bottoms or amongst mud, are not easy of detection. Though hitherto noticed in but few localities, they are probably more common than that circumstance might lead one to suppose.

Cytheridea, Bosquet.—Upper antennæ (Fig. 8), robust, five-jointed and strongly spinous, the last joint narrow and elongated; lower antennæ four-jointed, flagellum long and slender. Right foot of the first and second pairs in the male different from the rest, that of the first pair very strong and prehensile, of the second very feeble, the apical portion rudimentary and not clawed. Shell subtriangular, highest in front, thick; surface smooth, closely pitted, or concentrically rugose. Hinge-joint formed by two crenulated elevations of the right valve, which are received into corresponding depressions of the left. Habitat, mostly marine.

C. elongata, Brady; *papillosa*, Bosquet; *Zetlandica*, Brady; (?) *subflavescens*, Brady; *punctillata*, Brady; *torosa*, (Jones); *lacustris* (G. O. Sars); *dentata*, G. O. Sars.

The genus Cyprideis, Jones, is here united with Cytheridea. Of the species enumerated, all are marine excepting *C. lacustris* and *torosa*, the former of which occurs in fresh water, but seems to be excessively rare; the latter mostly in brackish, though it has in one or two instances been found in fresh water. In the brackish pools of our salt marshes, and amongst estuarine mud, it often occurs in prodigious numbers. The powerfully chelate right foot of the first pair in the male is a remarkable character of this genus, and is interesting as showing a similarity of plan between this and other tribes of Entomostraca where the right and left limbs of the male exhibit analogous differences of structure. Somewhat similar differences occur likewise in other genera of Ostracoda, but they are especially well marked in Cytheridea. It may be noted that the male of *C. lacustris* has not yet been observed either in Norway or in this country, so that its place in this genus is merely provisional. Its only known British habitats are the North Shaws Loch, Selkirkshire, and the Glasgow and Paisley Canal, where it was found by Mr. D. Robertson.

Cytheropsis, G. O. Sars.—Antennæ much as in Cythere, except that the lower are much more robust. Incisive portion of the first maxilla weak, internal segment rudimentary. Second pair of maxillæ very large and much dilated at the apex, flabelliform, and beset with numerous setæ. Feet alike in male and female. Shell high and compressed in front, depressed and tumid behind; thin, pellucid, and marked with round white papillæ. Marine.

C. declivis (Norman), *Argus*, G. O. Sars.

Ilyobates, G. O. Sars.—Upper antennæ very stout, five-jointed, the first two joints much thickened. Feet very short, the first two pairs three, the last four-jointed. Right foot of the last pair in the male prehensile, and only three-jointed,

terminal claw very large and strong. Eyes wanting. Shell thin and pellucid, subovate, truncate behind. Marine.

I. prætexta, G. O. Sars.—This curious species is at once distinguished by its elongated ovate form and truncate posterior extremity, which is also centrally emarginate. It occurs very sparingly in our seas, having been found only on the Dogger Bank and on the west coast of Scotland. The absence of eyes is accounted for by its habit of burrowing in soft mud.

Loxoconcha, G. O. Sars.—Upper antennæ very slender, six-jointed, the last joint very long, linear, and bearing only long, simple setæ. Lowest seta of the branchial plate of first jaw deflexed. Feet long and slender, alike in male and female. Abdomen terminated by a hairy conical process; post-abdominal lobes bearing two long subequal setæ. Shell subrhomboidal or peach-stone shaped, surface mostly marked with regular concentric pittings and small papillæ, sometimes with deep polygonal excavations; posterior dorsal angle obliquely truncate. Hinge formed by four small teeth, two on each valve.

L. impressa (Baird); *granulata*, Sars; *elliptica*, Brady; *tamarindus* (Jones), *guttata* (Norman).

Identical with the genus Normania, described by me in the "Transactions of the Zoological Society of London," Vol. v.: the name Loxoconcha is however of prior date. The species are all marine, except *L. elliptica*, which inhabits brackish water.*

Xestoleberis, G. O. Sars.—Upper antennæ six-jointed, the last four joints gradually decreasing in length and bearing very short, simple setæ. Feet short, post-abdominal lobes bearing two setæ. Ova and immature young borne within the shell of the female. Shell smooth and polished, ornamented with small round papillæ, depressed in front, in the female very tumid behind. Hinge formed by a dentated crest of the left, which is received into a corresponding excavation of the right valve.

X. aurantia (Baird); *depressa*, G. O. Sars.—Zenker and Sars both agree in the statement that the animals of this genus are viviparous; a point which I have myself had no opportunity of investigating.

X. depressa is a common inhabitant of deep water, while *X. aurantia* is found almost exclusively between tide marks. The former is pearly white, exhibiting most beautiful iridescent tints, and sometimes deeply tinged with red at the anterior extremity. The latter is yellowish brown in colour, and has no iridescence.

* The remaining genera are entirely marine.

Cytherura, G. O. Sars.—Upper antennæ shortly setose, six-jointed; lower, five-jointed, terminal claws very short. Feet small, the terminal claws short and curved. Male copulative organs very complex, provided with several irregular processes and a very long spirally convoluted tube. Valves unequal and dissimilar in form, the right overlapping on the dorsal margin; produced into a more or less prominent beak behind; surface smooth or variously sculptured, mostly marked with a central areola of darker colour than the rest of the shell.

C. nigrescens (Baird), *angulata*, Brady; *striata*, G. O. Sars; *lineata*, Brady; *cuneata*, Brady; *Sarsii*, Brady; *similis*, G. O. Sars; *undata*, G. O. Sars; *producta*, Brady; *affinis*, G. O. Sars; *gibba* (Müller); *Robertsoni*, Brady; *cornuta*, Brady; *acuticostata*, G. O. Sars; *clathrata*, G. O. Sars; *cellulosa* (Norman).

The members of this genus are the most minute, speaking generally, of all the Cytheridæ, and the specific differences are not always very clear; more extended observation will, doubtless, reveal many more species. Those now known inhabit chiefly deep water; but *C. nigrescens*, and occasionally some others, are to be found in tidal pools. Several species are found fossil in the glacial clays. The most striking peculiarity of the genus is the production of the shell into a prominent beak or rostrum behind: the surface of the shell is often irregularly waved or ribbed.

Cytheropteron, G. O. Sars.—Upper antennæ five-jointed, shortly setose, penultimate joint elongated. Feet long and slender, abdomen ending in a long, narrow process. Male copulative organs armed behind with three spiniform processes, one of which is trifurcate. Eyes wanting. Valves unequal, the right overlapping above, produced towards the ventral margin into a broad lateral ala, and forming behind an obtuse beak. Surface marked with shallow round or angular depressions, or with transverse ribs and furrows.

C. subcircinatum, G. O. Sars; *latissimum* (Norman); *nodosum*, Brady; *punctatum*, Brady; (?) *multiforum* (Norman).

A genus well characterized by the strongly projecting lateral alæ, and great tumidity, in which, however, some species of the following genus very closely resemble it:—

Bythocythere, G. O. Sars.—Upper antennæ seven-jointed, second joint very thick, and having a single seta on each margin; the other joints much narrower, forming a slender setose lash. Mandibles constricted above the distal extremity, and bearing a well-developed branchial plate. Branchial plate of second maxilla large, numerously ciliated, the four lower cilia deflexed. Feet elongated; basal joint of the first pair

bearing a small lobe, from which spring two large and two small setæ. Abdomen ending in a very long acuminate process; post-abdominal lobes narrow, bearing three hairs. Valves unequal, smooth, or sparingly sculptured.

B. simplex (Norman); *turgida*, G. O. Sars.—It would not be supposed, from the external appearance of these two species, that they ought to be referred to one and the same genus; their anatomical characters, however, seem to agree closely. The former is a much elongated species, acutely pointed at the posterior extremity; the latter very tumid, subtruncate behind, and much resembling, in general contour, the preceding genus: it is pretty generally distributed, while *B. simplex* appears to be confined to Scotland and the northern part of England. *B. simplex* approaches a form described by Professor T. Rupert Jones from fossil specimens under the name *Bairdia Harrisiana*.

Pseudocythere, G. O. Sars.—Upper antennæ seven-jointed, bearing long setæ; second joint thick and armed with a single seta in front; last joint long and narrow, terminated by very long setæ: lower antennæ very slender. Mandibles small and weak. Three lowermost setæ of branchial plate of first maxilla deflexed. Feet very long and slender. Abdomen ending in a long slender process. No eye. Shell thin and pellucid, rounded in front, produced at the postero-dorsal angle.

P. caudata, G. O. Sars.—This genus contains only one species, which is a very remarkable one, and apparently uncommon. The shell is subquadrangular in outline, and so much compressed as to appear almost squamous at the posterior ventral extremity, where it is once or twice minutely toothed. Colour brown, owing to the transparency of the shell, through which the animal itself is seen. Its range is extensive; the few British specimens yet taken are from Connemara, Northumberland, Shetland, and the Channel Islands.

Cytherideis, Jones.—Carapace as seen from the side, much attenuated in front, highest behind. Hinge margins nearly simple: right valve overlapping the left in the middle of the ventral surface. Animal unknown.

C. subulata, Brady.

The name Cytherideis was proposed by Professor T. Rupert Jones, for a group of species which agreed in presenting a peculiar hinge structure, the margin of one valve projecting in a sort of angular crest, the other being cut away, so as to receive it. The genus was not in any case very definite in its characters, and its members must now be looked upon as distributed amongst several other genera; but the species above-named (*C. subulata*) cannot at present, from want of

knowledge of its anatomy, be certainly classed under any other head; the overlapping right valve precludes the notion of its belonging to *Paradoxostoma*, with which, in other respects, it shows considerable agreement. I therefore retain for it the name Cytherideis. This species is described by Dr. Baird as *Cythere flavida*, Müller; but the two are most probably quite distinct: the latter species appears to be a yellow variety of *Paradoxostoma variabile*.

Sclerochilus, G. O. Sars.—Antennæ robust, the lower larger than the upper; flagellum long and very slender; poison glands large and many-lobed; mouth produced, conical; labrum strongly toothed; mandible small; terminal lobes of the first pair of jaws partially wanting; branchial plate narrow, almost lanceolate; feet short and robust, the first pair having a strong spine at the apex of the basal joint; post-abdominal lobes very large; valves elongated, hard, especially at the edges; surface smooth and shining.

S. contortus (Norman).—This species shows, in the structure of the mouth and mandibles, a state intermediate between the typical Cytheridæ and Paradoxostoma.

Paradoxostoma (Fischer).—Upper antennæ exceedingly slender, six-jointed and shortly setose; lower shorter and more robust, five-jointed, flagellum very large and stout; poison glands large, lobulated; mouth suctorial; labrum and labium forming together a large and stout subconical process, projecting downwards, and terminating in a disk, in the middle of which the orifice of the mouth is situated. Mandibles very slender, protractile, styliform; palp very slender, and without a branchial appendage. Terminal lobes of the first maxillæ very narrow, two lower setæ of the branchial plate deflexed. Feet short and robust, last joint elongated, terminal claws short and curved; basal joint of the first pair bearing a single strong spine; one eye; shell thin and fragile, having no definite structure; valves subequal, mostly higher in front than behind; ventral margins emarginate in front, so that when the valves are closed there is left an elongated orifice, through which the suctorial apparatus can be protruded.

P. variabile (Baird); *abbreviatum*, G. O. Sars; *Normani*, Brady; *pulchellum*, G. O. Sars; *obliquum*, G. O. Sars; *Hibernicum*, Brady; *Sarniense*, Brady; *ensiforme*, Brady; *flexuosum*, Brady; *arcuatum*, Brady.

The remarkable suctorial mouth of these animals at once separates them from all other genera, and even without examination of the internal parts, the shell itself gives evidence as to its affinities by the longitudinal aperture between the two valves on the anterior portion of the ventral surface; this opening, through which the mandibles and mouth can be protruded, is

usually very distinct. Sars considers it most likely that these creatures derive their nutriment from the juices of the fuci, etc., amongst which they are usually found, for though the structure of the suctorial apparatus is very much akin to that of the parasitic Entomostraca, none of the Ostracoda have ever been found as parasites. It is, indeed, impossible to regard the members of this genus as parasitic, but neither do I think it likely that the poison gland and urticating setæ, which are with them very largely developed, can be meant to assist the creatures to prey upon *vegetable* food. It seems more likely that they serve an office similar to the urticating filaments of the Actiniæ in paralyzing the more minute animal organisms on which their owners probably subsist.

The genus is an especially littoral one, almost all its members being met with in tidal pools, though some of them range also into and beyond the Laminarian zone. The shell is usually very thin, pellucid, and variously marked with shades of olive, deep purple, or black.

Family—Cypridinidæ, Baird.

Philomedes, Lilljeborg. — Upper antennæ six-jointed, scarcely attenuated at the apex, antepenultimate joint bearing a stout seta, which is set with numerous long auditory cilia; last joint short, and bearing two setæ, which are much longer than the antenna itself. Secondary branch of lower antenna, three-jointed, geniculated, last joint turned upwards. First pair of jaws slender, palp bearing simply a small trisetose lobe; second pair having neither a mandibuliform appendage, nor clawed spines. Animal swimming with long jerks.

P. interpuncta (Baird).—This is the most abundant of the British Cypridinidæ, being sometimes taken in considerable numbers by the towing-net, and occasionally in tidal pools. It ranges, in our islands, from Guernsey to Shetland. The shell is thinner than in others of the family, and often finely reticulated on the surface. Identical with *P. longicornis*, Lilljeborg.

Cylindroleberis, nov. gen.—Upper antennæ of the *male* (Fig. 11) bearing at the apex two excessively long, annulated setæ, four shorter setæ and a short curved claw; penultimate joint bearing at its apex a stout, densely ciliated auditory seta; upper antenna of the *female* (Fig 12) terminated by a stout curved claw, and six or seven subequal plumose setæ, which do not exceed in length that of the last four joints; penultimate joint bearing a stout seta or process, from the extremity of which spring six similar setæ. Second joint of the natatory

branch of the lower antenna in the *male* elongated; in the *female* scarcely longer than the succeeding joints; secondary branch in the *male* (Fig. 13) robust, subchelate, terminal joint slender, curved upwards; in the female simple, triarticulate, last joint setiform. Antepenultimate joint of the mandibular foot shorter than the following joint, bearing three long subequal curved setæ, two of which are plumose; last joint very short, armed with a curved claw and several setæ. First maxilla, consisting of a broad subquadrate or crescentic lamina, densely clothed on its distal side with long bristles; second pair swollen at the base, suddenly narrowed toward the apex, interruptedly setose; third narrow, uniformly setose. Oviferous foot terminating in two equal dentate lips (Fig. 14), and bearing about six pairs of spinous setæ. Shell elongated, fusiform, or subcylindrical, smooth; beak rounded, and not at all produced; notch narrow. Animal swimming freely.

C. Mariæ (Baird), *teres* (Norman).—Mr. Robertson takes these species in the Frith of Clyde (though never very abundantly) by means of the tow-net, during the night. It would seem, indeed, that these animals do not come to the surface except after sunset. This observation suggests that possibly in fresh-water lakes something might be done by naturalists during the "wee sma' hours ayont the twal."

Bradycinetus, G. O. Sars.—Terminal setæ of the upper antenna short and subequal. Secondary branch of the lower antenna in the *female* (Fig. 15) small and biarticulate, the last joint obtuse, and bearing at the apex a flexuous seta; in the *male* larger, three-jointed, the last joint long and membranaceous, terminating in two short setæ. Mandibular feet (Fig. 16) armed with a bifurcate process, in front of which are three toothed spines. Second pair of jaws having a strong mandibuliform appendage, composed of two robust tooth-like processes. Eyes small, and of pale colour. Animal mostly crawling slowly amongst mud. Shell much thicker and stronger than in the preceding genera, produced in front into a large beak, with a deep subjacent notch.

B. Brenda (Baird), *MacAndrei* (Baird).

Family—Conchoeciadæ.

Conchoecia, G. O. Sars.—This is the only genus of the family, and is sufficiently described previously (pp. 115, 116).

One specimen only has been seen in Britain, and is probably referable to *C. obtusata*, G. O. Sars. It was found by the Rev. A. M. Norman, in sand dredged off Shetland.

Family—Polycopidæ.

Polycope, G. O. Sars.—The principal characters of this genus are those of the family to which it belongs, and of which it is the only member.

P. orbicularis, Sars.; *dentata*, Brady.—The first-named species is probably not very uncommon, but owing to its small size—$\frac{1}{50}$th of an inch—is very likely to be often overlooked. It has occurred in Connemara, Shetland, and the West of Scotland. The shell is almost spherical, and often beautifully punctate and marked out into polygonal areolæ. Of the second species only one example has yet been found; this occurred to Mr. Norman in the same gathering as that which yielded the Conchoecia. According to the investigations of G. O. Sars, these animals are wonderfully active in the water, having no less than ten limbs adapted for swimming.

Family—Cytherellidæ.

Cytherella, Bosquet.—The anatomical structure has been noticed in the description of the family. The shell is very thick and dense in structure, the lateral outline mostly elliptical, and the hinge formed by a simple grooving of the edge of one valve into which the margin of the opposite valve is received. The "lucid" spots* are arranged in a curved pinnate series.

C. Scotica, Brady; *lævis*, Brady.—Both species are very rare, and hitherto have been found only amongst the Hebrides. The former is closely allied to a Norwegian species described by Sars—*C. abyssorum*. Several fossil species have been described by various authors; the great thickness and durability of the shell may perhaps account for this.

Explanation of Plate I.

Fig. 1.—Illustrating the anatomy of the female of the genus *Cypris*: *a*, eye; *b*, upper antenna; *c*, lower antenna; *d*, mandible proper; *e*, its branchial appendage; *f*, its palp; *g*, first maxilla; *h*, its branchial plate; *i*, second maxilla, with branchial appendage; *j*, first foot; *k*, second foot; *l*, abdomen; *m*, post-abdominal ramus; *n*, alimentary canal; *o*, ovary.

Fig. 2 illustrates the anatomy of the genus *Cythere*: the letters used refer to the same organs as in *Cypris*, except those

* These, though existing in all Ostracoda, have not, for the sake of brevity, been previously noticed, though they sometimes afford good generic characters. They are, in fact, thin, depressed portions of the shell which afford attachment to the muscular bands by which the animal is attached, and by which it is enabled to close the valves firmly.

following: *r*, *s*, *t*, first, second, and third feet; *v*, poison gland, communicating with the urticating seta (flagellum) of the lower antenna.

Fig. 3.—Rudimentary post-abdominal ramus of *Cypridopsis*.

Fig. 4.—"Glandula mucosa" of male *Candona candida*.

Fig. 5.—Second foot of *Pontocypris mytiloides*.

Fig. 6.—Post-abdominal ramus of *P. trigonella*.

Fig. 7.—Upper antenna of *Limnocythere inopinata*.

Fig. 8.—Upper antenna of *Cytheridea papillosa*.

Fig. 9.—Abdomen and post-abdominal setæ of *Cytheridea torosa*.

Explanation of Plate II.

Fig. 10.—Illustrating the anatomy of Bradycinetus (adapted from Lilljeborg): the letters are used with the same references as above, except the following: *r*, secondary branch of lower antenna; *s*, mandibular appendages of branchial plate of second maxilla.

Fig. 11.—Upper antenna of male *Cylindroleberis Mariæ*.

Fig. 12.—Upper antenna of female *Cylindroleberis Mariæ*.

Fig. 13.—Secondary branch of lower antenna of male *Cylindroleberis Mariæ*.

Fig. 14.—Termination of oviferous foot of *Cylindroleberis Mariæ*.

Fig. 15.—Secondary branch of lower antenna of female *Bradycinetus MacAndrei*.

Fig. 16.—Mandibular foot of *Bradycinetus Brenda*.

Fig. 17.—Termination of oviferous foot of *Philomedes interpuncta*.

Fig. 18.—Post-abdomen of *Philomedes interpuncta*, seen from below.

AN APRIL CLIMB IN THE HIMALAYAS.

BY GEORGE E. BULGER,

Captain, 10th Regiment.

THE morning of April 6th, 1867, looked rather more promising than usual.* The sun peeped out at intervals from the light cumuloid clouds that screened the eastern heavens; and even the white peaks of the snowy range were faintly visible when we started from our residence on the west side of Jella Pahar, with the intention of walking to the summit of the great mountain called Sinchul, distant, perhaps, some six or eight miles from Darjeeling, and 8600 feet above the level of the sea. This noble hill—one of the loftiest in British Sikkim—is a grand and striking object from any point of view; and its numerous spurs and ramifications furnish nearly all the greater summits in the neighbourhood, upon which are built the stations of Jella Pahar and Darjeeling, and the settlements of Leebong, Tukvar, Dooteriah, Senadah, and Hope Town.

Having crossed the ridge of Jella Pahar, we found ourselves in the main road, leading, with a gentle slope, from a dip in the mountain called the "saddle" to the Sinchul barracks, which are situated fully six hundred feet higher up. But before we had gone very far, great piles of mist began to rise from the khuds and valleys below, ever and anon shutting out the view of all objects beyond a hundred yards, and threatening, ere long, to shroud the entire prospect, for the remainder of the day, in a dense mantle of heavy cloud.

The road winds slowly upwards, passing through the mutilated remains of glorious forests, that once overspread this mountain-side from base to summit, but which now, alas, in the vicinity of the highway and the military station, are very nearly obliterated from the soil that fed and nourished them, for, perhaps, thousands of years before the axe or the clearing-fire brought destruction amidst some of the fairest scenes on earth. But, even here, all the trees are not yet gone, and aged giants of towering height and huge proportions, gnarled, moss-covered, green with orchids, and festooned with climbers, still stand, among the unsightly stumps of their departed brethren, perfect marvels of magnitude, grandeur, and solemn majesty.

The walk to Sinchul is, to me, a somewhat melancholy one,

* The weather at Darjeeling and its vicinity has, this year, been almost continually cloudy since the end of March, as, possibly, before that time also.

owing to the wholesale destruction that has smitten these splendid woods, and to the continual sound of the fatal axe, which alone seems to break the stillness of the solitude, announcing, but too plainly, the inevitable doom that hangs over the face of nature in this region.

Amongst the multitude of trees which make up the forests of the Lower Himalayas, the magnolias and rhododendrons are most striking; and, in the season of bloom, their splendour exceeds, perhaps, anything else of the kind in the world: not that the trees are individually handsomer or finer than many other objects of the vegetable kingdom, but their great size, immense numbers, and profuse inflorescence, and last, not least, the localities where they grow—on the summits and slopes of the hills—which are eminently adapted to show them to the best advantage, come upon the observer in such grand combination as utterly to set aside the lesser, but, perhaps more brilliant glory of more contracted views.

Magnolia excelsa, a lofty and stately tree, displays an almost incredible number of white, fragrant flowers, which render even a solitary specimen conspicuous amidst the greenery of the woods fully a mile away; *Rhododendron argenteum* crowns the summit of the hills, and its glistening and silvery blossoms, in the aggregate, present to the beholder, at a distance, much the same effect as that of a recent fall of snow; and *Magnolia Campbelli*, a contorted and ungainly giant, at present without leaves, and with few and unsymmetrical branches, offers such a glorious show of rose-purple flowers that it must, in truth, be acknowledged as the pride of these mountain woods. It does not grow on the lower hills, but is abundant near the summit, and on the upper slopes.

Wild-flowers are, as yet, far from plentiful, a hardy few, only, having opened their blossoms to greet the returning spring; but, conspicuous from its brilliant azure and extreme beauty, the little *Gentiana coronata* cannot fail to attract attention, and elicit warm admiration. A purple foxglove and a pale violet (*Viola repens*) are also abundant; and, on the higher altitudes, the familiar forms of many other European genera, speak home to the heart of the traveller, who welcomes the little, humble-looking plants of his boyish recollections with thrice the warmth accorded to the more gorgeous children of the eastern sun.

Animal life is scarce in these dark, moss-grown, mysterious forests, reeking with moisture, and abounding in the most wondrous forms of the vegetable world; and even the occasional note of some lonely bird breaks on the ear as wild, and strange, and out of place, amidst the vastness of the solitude, where, it would almost seem, man stood apart from earth, and in

the near presence of his Maker.* During the first part of the ascent, I only observed, in addition to a few tits and warblers, which I could not identify, the white-throated fantail (*Leucocerca fuscoventris*) and the verditer flycatcher (*Eumyias melanops*); while, higher up, the little chestnut-headed wren (*Tesia castaneo-coronata*) seemed to be the sole occupant of the woods.

The promise of the morning was not fulfilled; and, ere we had half completed the distance between our starting-point and our destination, we were enclosed in a fog so thick that we could hardly trace the path before us. Blindly following the track amidst this comparative gloom, and clambering over trees and slippery banks of moist and greasy earth, we at last completed the ascent of what we supposed was the highest point of Sinchul, and, sitting down, waited patiently for the atmosphere to clear. It did so, partially, for about ten minutes, and disclosed, not the grand panorama we had anticipated, for the clouds still lay in heavy masses all round the neighbouring hills, but the disappointing fact, that, instead of being, as we imagined, upon the apex of the mountains, we had only attained to one of the lesser summits, which had been cleared of trees for surveying purposes. It was too late in the day, and there was too little hope of a view, to induce us to complete the ascent to the highest peak, so, bidding adieu to the place until some brighter season, in the midst of the thick fog, which had again overspread the country, we descended from our lofty position, and trudged back towards Darjeeling, passing on our way a black and gloomy-looking little patch of water, which seemed more like a rain-puddle than the mountain-tarn I supposed it to be.

From the summit of Sinchul, in clear weather, is to be obtained a wide and marvellous view of the Nepal, Sikkim, and Bhotan Himalayas, presenting to the beholder a great and almost graduated crowd of mountains, extending from the lesser hills in the valley of the Great Runjeet river to those matchless tiers of snowy peaks which cluster round the stupendous mass of Kinchin-junga, and afford a prospect which, for grandeur and sublimity, has no parallel on earth.

* My subsequent experience of these forests has shown that the scarcity of birds, on the occasion referred to, was owing chiefly to the earliness of the season; for, by the middle of May, the woods were full of feathered creatures, and fairly ringing with the clear, metallic whistle of the black-headed sibia (*Sibia capistrata*).

ELECTRICAL COUNTRIES, AND THEIR ACTION ON THE WEATHER.

BY M. J. FOURNET.

(*From "Comptes Rendus," 1st July*, 1867.)

It cannot be otherwise than interesting, in a scientific point of view, to ascertain whether or not there exist certain countries more electric than others; for, besides the strangeness of such a fact, it is not impossible that meteorological reactions may be produced, even at great distances, from unequal distribution of electricity.

The persevering studies of De Saussure, combined with those of other physicists, have made us accurately acquainted with what occurs in our regions in ordinary weather; and, in addition to this, many travellers have recorded certain highly curious effects which usually manifest themselves in remote countries; and, lastly, my own endeavour to add to our information on the storm action of the south-west, have led me to the idea that it may bring us electricity, excited on the other side of the Atlantic. It remains, therefore, to ascertain whether there are in existence any facts which may confirm such ideas.

On consulting the important work on Mexican Hydrology by M. H. de Saussure, grandson of the great explorer of the Alps, we see that, at the end of winter, dryness becomes excessive in the elevated plateaux of that country, where evaporation is immense. No vapours then disturb the purity of the sky, and the exhibition of electric sparks at the approach of various objects takes place at times with remarkable intensity.

This tension is even sustained in the rainy season, for in 1856, when M. H. de Saussure and M. Peyron ascended the Nevada de Toluca, in spite of the reiterated warnings of the inhabitants, they soon found themselves enveloped in a frost-fog—a menacing symptom of the storm which was coming on. Soon came a violent wind, with hoar-frost, then lightning and thunder, pealing incessantly and with a frightful noise, obliged them to descend lest they should be struck with the discharges. At a lower elevation the storm appeared to calm itself for a moment, and the travellers were enveloped in a grey fog, accompanied with hoar-frost; and they noticed the hair of their Indian guides in agitation, as if about to rise up. Soon there came a dull, indefinable sound, at first weak, though in all directions, and then growing stronger and stronger, very distinct, and even alarming. It was an uni-

versal crepitation, as if all the little stones on the mountain were jostled together. After a lapse of five or six minutes, thunder came on again, and rain, which lasted to the borders of the forest region, when the storm became more endurable, partly from the greater distance of the focus of electrical disturbance; and also from partial discharges which were promoted by the vegetation.

Previous to this, M. Craveri, a Mexican physician, had been present at a similar spectacle, on the 19th of May, 1845, when it was suddenly induced by a cloud coming from the north-west. The guides and himself experienced electrical sensations at all their extremities—their fingers, noses, and ears, followed by a dull sound, though no thunder was heard. The long hair of the Indians became stiff and erect, giving their heads an appearance of enormous size, and thus aggravating their superstitious terrors. The noise at length grew more intense. It appeared to extend throughout the mountain, and was like the rattling of flints, alternately attracted and repulsed by electricity; but was probably due to the tapping sound of innumerable sparks starting from the rocky soil. In this case no hoar-frost came on.

The same observer experienced another storm on the 15th of September, 1855, near the summit of Popocatepetl, which differed from the preceding one only that, taking place on the snow-fields, there was no crepitation of stones.

These Mexican storms, which remind me of less striking results observed in the Alps, have been noticed in May, August, and September—that is to say, in the most stormy period for Europe; and the coincidence ought not to be neglected. It will also be remarked that the storm of the 19th of May, 1845, was brought on by a west wind.

Phenomena of another kind have been observed at Chihuahua, in the Mexican Confederation, but more north. New York has supplied Professor Loomis with an assemblage of facts not less curious, in connection with the presence of an excessive quantity of electricity in the atmosphere. In the winter, hair frequently becomes electrical, especially when a fine comb is used. The greater the efforts made to smooth the hair, the rougher it becomes. It moves towards the fingers that approach it, and the only way to remedy this inconvenience is to make it damp.

At the same seasons woollen clothes, especially trowsers, attract particles of down or floating dust. These particles collect chiefly towards the feet, and brushing makes them stick tighter; a damp sponge is the only mode of removing them. During the night, thick carpets in hot rooms crackle and shine when walked over. By passing over them two or

three times rapidly, sparks of some centimetres in length are obtained, and give noticeable pricks. A metallic object, such as a door-handle, shoots a spark at the hand which approaches it; and sometimes these discharges frighten the children. Occasionally a gas jet may be lit with a finger after walking on the insulating carpet.

These phenomena are so common in New York that they excite no surprise; but they attracted the attention of Volney at the close of the last century. This celebrated traveller observed that the quantity of electricity present in the air constitutes an especial difference between America and Europe. "The storms, also," he said, "furnish frightful proofs of this, by the violence of the thunder, and the prodigious intensity of the lightning." At Philadelphia, the sky seemed on fire from their rapid succession; and their zigzags and darts were of a magnitude of which he had no idea.

The extreme dryness of all the plateaux of the Andes occasion similar effects; and, according to M. Philippi, in the desert of Atacama, men's hair is often made to stand on end, and luminous manifestations spring from the ground.

According to Dr. Livingstone, in spring, which is the season of greatest dryness, the deserts of South Africa are often traversed by a hot north wind, so electrical, that the feathers of the ostrich become excited to active movements; and the slightest friction of clothing gives rise to luminous jets. And, as Volney noticed in America, the heat of the tropical season is not essential to this abundance of electricity, as it is never so striking as when a cool wind blows from the north-west; and the observations of Gmelin, Pallas, Muller, and Georgi, show that it is not less excessive in the glacial atmosphere of Siberia.

In India, electric disturbances in the atmosphere occasion remarkable difficulties in working telegraphic lines. The apparatus seems delirious, and works backwards and forwards. Storms of dreadful violence tear up the posts, and threaten to melt the wires; so that, as a narrator observes, we need not be surprised that Indian telegrams are often as puzzling as the cuneiform inscriptions on Babylonian bricks.

It would be easy to multiply further evidence of the same kind; but this may suffice to show that in the east, the south, and the west, electrical actions influence meteorology, and we may be permitted to believe that their influence may be brought to us by the winds.

RAINBOW PHOSPHORESCENCE.

UNDER this title we propose to describe a series of curious preparations made in France with great perfection, and capable, after exposure to sunshine, electric light, or magnesium light, of emitting in a dark chamber, very beautiful luminous effects, red, blue, yellow, and green. The substances sold for this purpose are enclosed in long flat bottles, and placed side by side in a box, the lid of which is removed when the experiments are made. The origin of all such preparations may be found in the "Bologna phosphorus," well known to all chemical students. It appears that in 1602 Vincenzo Cascirolo, an artisan of Bologna, engaged in alchemical pursuits, accidentally made a phosphorescent sulphide of barium by calcining sulphate of baryta in contact with charcoal, and this material, which attracted the greatest interest amongst philosophers, was subsequently named the "Bologna stone," or "Bologna phosphorus." In 1675 Baudouin described a similar preparation made by calcining nitrate of lime, and named it "hermetic phosphorus." To prepare Bologna phosphorus, sulphate of baryta is reduced to powder, moistened with water or white of egg, and made into cakes, which are placed in layers of *braise* (charcoal ashes), and calcined in a furnace.

In his recent work on light, M. Becquerel* states that Margraf, who published an account of his experiments in 1862, by pulverizing and calcining these substances two or three times in succession (as recommended by Pothier), obtained a mixture of phosphorescent tints, and thus to some extent anticipated the more recent preparations we shall proceed to describe. At the end of the sixteenth century, Homberg introduced his phosphorus made from chloride of calcium; and in 1730, Dufay published a memoir, showing that many minerals, shells, and calcareous concretions exhibited similar properties after calcination; and Beccaria soon afterwards demonstrated that insolation, or exposure to sun-light, imparted the property of phosphorescence to a considerable number of dried organic substances, and other materials. In the course of his experiments Beccaria devised a phosphoroscope, or rotating apparatus, for exposing a substance to the light, and then exhibiting it to an observer situated in the dark. By these means, which have been improved in later times, a very slight degree of phosphorescence may be rendered visible. Zanotti, secretary of the Bologna Academy, about the same time observed that

* "La Lunière ses Causes et ses Effets," par M. Edmund Becquerel, de l'Academie des Sciences, de l'Institut de France, Professeur au Conservatoire des Arts et Métiers, etc. Paris: Firmin Didot. 1867.

the Bologna phosphorus emitted one shade of colour without reference to the part of the solar spectrum to which it was exposed.

In 1764, Canton introduced the so-called phosphorus bearing his name, and as his method was easy to follow, it was very generally adopted. He calcined oyster-shells in a crucible, powdered the resulting substance, mixed it with one-fourth its weight of sulphur, and kept it a red heat for one hour. The result of this process is a sulphide of calcium, which, after exposure to light, shines in the dark with a green or yellow lustre, according to the details of its preparation. "Canton," observes M. Becquerel, "showed that the light of a candle, of the moon, or of electric sparks, rendered this substance active. He also showed that heating it in the dark did not render it luminous unless it had been previously exposed to the light, and that if heated immediately after such exposure, its action was more energetic than when it was heated a few days afterwards. Thus, heat occasions a rapid emission of light that would have been very slowly given forth at ordinary temperatures. Canton also showed that if at the end of several months this substance, previously insolated, was heated with boiling water, it gave no result; but when the heat was carried to a temperature of about 500° (C.), it became luminous, and then fell back to its inactive state until revived by a fresh insolation."

In 1780 Wilson published his experiments on the prismatic colours exhibited by phosphorus. He noticed that different portions of calcined oyster-shells exhibited different phosphorescent tints, red, yellow, green, or blue, and he separated them accordingly. Wilson also confirmed the statements of Dufay and Zanotti, that each portion of his calcined shells emitted their peculiar light, whatever might be the colour of the exciting rays; thus his red luminous fragments, he said, emitted a red light in the dark, whether placed in the violet, the blue, or the red of the spectrum, and the luminous portions exhibited a green phosphorescence after the action of violet, blue, or red rays. M. Becquerel remarks that these experiments were partly vitiated by the employment of an imperfect spectrum. His own researches show that the blue and violet rays act more energetically than the red, and that with Canton's phosphorus the red not only give no illumination, but exert a destructive power. A similar observation had been previously made by Goethe and Seebeck, and M. Becquerel cites the following passage from the work of the former on colours:—"The Bologna phosphorus becomes luminous under the influence of blue and violet glass, and never under yellow or orange glass; and it may be remarked that this phosphorus rendered luminous by blue or violet colours becomes extin-

guished sooner in yellow or orange rays than if placed nearly in a dark chamber. If these experiments are repeated with a prismatic spectrum the same results are always obtained."

The Newtonian theory that light consisted in an emission of minute particles shot forth with great velocity, led the older philosophers to conceive that these phosphorescent bodies had bottled up the light, something like the cucumber of Laputa, and gave it back again, as the celebrated sage of that island desired to make the cucumbers do. Such notions, however, and the somewhat similar one, that they absorb light, as sponges absorb water, are quite inconsistent with some important facts, and with the undulatory theory of light, which may now be considered as well established. M. Becquerel observes that such comparisons are incorrect, inasmuch as the light emitted usually differs from that which excites the phosphorescent body. Phosphorescence is generally an emission of light-waves of less velocity than those of the rays which excited it.

The most luminous of these phosphori are the sulphides of alkaline earths, calcium, barium, and strontium. The first gives Canton's phosphorus emitting a yellow or a green light; the second, the Bologna phosphorus, for the most part orange. M. Becquerel remarks that "these substances, when well prepared, will shine in darkness for many hours after their exposure to solar action, decreasing, however, rapidly in lustre in the first moments, and then growing weaker more slowly. Their light is emitted in vacuum as well as in gases, and their action is not accompanied by any chemical effect; it is the result of a temporary physical modification. Amongst the metallic sulphides, those of strontium and barium exhibit the greatest vivacity of luminous emission, and those of calcium yield the greatest variety of colours."

A sulphide of zinc, formed in a particular way, is as phosphorescent as the sulphides of the alkaline earths. Other metallic sulphurets do not exhibit the property, not even those of the alkaline metals, and the other compounds of barium, strontium, and calcium, excepting their selenides, do not manifest energetic action of this nature. Following the sulphides just mentioned, come minerals, such as certain diamonds, especially those of a yellow tint, and most specimens of fluoride of calcium. The variety of calcic fluoride called chlorophane becomes very luminous by insolation, emitting a slightly bluish green tint of light. The reason why particular diamonds, or chlorophanes, are phosphorescent, while others do not exhibit that property, is at present unknown. M. Becquerel says, "the diamond and fluoride of calcium do not exhibit a vivacious lustre, but they remain luminous for a long time. Thus, I have

seen a fragment of green fluor spar and two white diamonds emit light for one hour after insolation."

In preparing these phosphori, it is noticed that the peculiarity of their luminous action depends on the primitive condition of the sulphates employed. "Thus the natural crystallized sulphate of baryta affords the orange yellow Bologna phosphorus; the natural sulphate of strontium from Sicily in rod-shaped (bacillary) crystals, yields a bluish green phosphorus, and if by the action of carbon different sulphates are reduced to the condition of sulphides, their luminous action will vary."

In preparing a phosphorescent sulphide with lime, or carbonate of lime, it is most convenient to add 85 parts of sulphur to 100 of the lime, or 48 to 100 of its carbonate. The materials are intimately mixed and placed in an earthen crucible in a charcoal furnace. M. Becquerel says it is necessary to pay attention to the temperature as well as to its duration. "Operating with fibrous arragonite, and heating the crucible to 500° (C.) for a time sufficient to allow the reaction between the lime and the sulphur to take place, and the excess of the latter to be eliminated, a feebly-luminous mass affording a bluish tint is obtained. If this mass is raised to a temperature of 800° or 900° (C.) and kept for five-and-twenty or thirty minutes at a point not exceeding the fusion of gold or silver, it yields a brilliant green light. The chemical composition is the same in both cases; but it is remarkable that if the process is conducted with carbonate of lime instead of with lime, the refrangibility of the light emitted does not vary with the temperature."

Too high, or too prolonged a temperature destroys the phosphorescence, and charcoal furnaces answer better than coke.

Among the lime preparations, those made with pure Iceland spar give, after insolation, an orange yellow light, calc spar affords a less vivid tint, Carara marble a very weak yellow light, oyster-shells yellow, chalk a scarcely visible yellow. Arragonite of Vertaison in bacillary crystals, a green of medium intensity, fibrous arragonite a dominant violet tint, with some parts green, and lime obtained from fibrous arragonite a very vivid green.

If nitric acid is employed to dissolve the lime of these minerals, and it is then precipitated by carbonate of ammonia, the tints of the phosphorescence will vary according to the sources of the lime.

Phosphori composed of strontium sulphides usually require less heat in their preparation than the lime series, and an excess of heat destroys their luminosity. The barium phos-

phori on the contrary are prepared with greater and more sustained heat. Chlorides of calcium and strontium tend to give blue and violet tints, those of barium yield green tints, while carbonates obtained from nitrates and acetates of baryta afford yellow orange phosphori, and analogous combinations of calcium and strontium give very luminous green ones.

A luminous orange phosphorus from barium is made by intimately mixing powdered crystalline sulphates with 12 to 15 per cent. of lamp black, moistened with a little alcohol. When the mass is dry it is calcined in a crucible for 45 to 60 minutes, at a temperature not exceeding cherry red, or the melting point of silver. The resulting mass is powdered and calcined a second time.

We have mentioned that, as a rule, these phosphori give the same tints whatever may be the colour of the light they are exposed to in order to excite them, but M. Becquerel cites three exceptional cases.

1. Sulphide of barium obtained by reducing the sulphate with lamp black, gives an orange yellow phosphorescence when illuminated by the action of the rays in the spectrum situated towards the end and beyond the violet (from lines H to P), while the effect of the rays from the blue to the violet (F to H) is to induce a redder phosphorescence.

2. The sulphide of calcium obtained from oyster-shells, which gives a red light when excited by rays from the blue (F) to the ultra-violet as far as O, has a green tint imparted to it when excited by the rays beyond O and P, which are non-luminous to human eyes.

3. A phosphorus obtained by the action of sulphide of potassium on oyster-shells, is excited to an indigo-violet luminosity by exposure to rays of that tint, while rays beyond the violet excite it to emit a blue colour.

It is interesting to observe from M. Becquerel's explanations and from a beautifully-coloured plate attached to his work, that while the most luminous parts of the spectrum, the yellow, actually exert a destructive effect on the light of these phosphori, they are all capable of excitation by non-luminous rays beyond its violet extremity.

We are afraid that experimenters will only succeed in making the more easy of their phosphorescent compounds, unless they possess a good deal of patience and considerable knowledge of chemical manipulation. When well prepared the varieties of colour are very distinct, and the luminous effects brilliant and pleasing. They not only afford an agreeable recreation, but they suggest curious speculations on the molecular condition of the several compounds. Light appears to excite a peculiar vibration of their particles without affecting

their chemical condition; and it is most remarkable that notwithstanding the chemical decompositions and recompositions that occur during the preparation of certain sorts, their final properties depend upon the original condition in which their alkaline earths were found.

THE ERUPTIONS AT SANTORIN.*

We have on several occasions laid before our readers various facts concerning the interesting volcanic eruptions at Santorin, and we have now before us a valuable paper on the subject, accompanied by large and beautifully-executed maps and diagrams.

The German philosophers to whom we are indebted for this work commence by pointing out certain resemblances between the Kaimeni, or "burnt," Islands of the Santorin group, and the volcanic region immediately surrounding and comprehending Vesuvius. The island of Thera, or Santorin, is approximately semicircular in form, and opposite to its western or concave side are two other islands, Therasia and Aspronisi—the latter being very small—which follow the general curvature of the main island, and with it enclose a sea-basin more than five miles in diameter, in the midst of which the Kaimenis rise. Von Buch, in accordance with his well-known theory, considered the whole formation to be "a crater of elevation," formed by the upheaval of the sea-bed; but examination in this, as in most other cases, dissipates his conjectures, and shows these Santorin volcanoes to have modified the surface by the outpouring of molten matter. MM. Fritsch, Reiss, and Stübel say, "Let us imagine Mount Vesuvius and Somma to be lowered, so that the sea might enter into and partly inundate the Atrio del Cavallo, we should then obtain a distribution of sea and land analogous to that seen at Thera and the Kaimeni Islands, a smaller part of the cone of Vesuvius rising from the sea in the midst of encircling Somma." Somma is, as most of our readers will know, the name given to the *ancient* cone, the remains of which partially surround the newer cone known as Vesuvius, and formed in 79 during the tremendous eruption in which the elder Pliny lost his life. After indicating the analogies between Vesuvius and Santorin, our authors point out the differences, and observe that "while on Mount Vesuvius the volcanic action has always been confined to the existing

* "Santorin: the Kaimeni Islands." From Observations by K. V. Fritsch, W. Reiss, and A. Stübel. Translated from the German.—Trübner and Co.

crater, at least so far that they have never raised by its side any other mound approaching in height and extent to the great cone, we find, in the Gulf of Santorin, each separate revival of volcanic action, characterized by its separate and special formation, which we can trace as such even under water down to a common base. These formations owe their origin to a slow emission of large masses of lava quietly overflowing at their point of issue, filling up the irregularities of the bed of the sea, and rising by degrees as islands above the water-level. The eruptions of Mount Vesuvius, on the contrary, are mostly distinguished by a totally different character, inasmuch as the melted rock, flowing from a higher or lower point of eruption down the slope of the mountain cone, spreads in long but narrow streams."

An interesting peculiarity of the volcanic action at Santorin is the fight which the volcanic fires have had with the cold water of the sea. "The quantity of steam sent forth at intervals of but a few minutes was so considerable, that it often rose to a column of more than 2000 metres in height."* This magnificent display lasted for months, and acting upon the tough, viscid lava, assisted to produce the crater forms.

On the 16th of May, 1866, without previous symptoms of disturbance, two small islands appeared in the Kaimeni group. "No signs of anything occurring at the bottom of the sea had preceded this event, except that new soundings showed a depth less than that which had been previously observed in the channel." The new islands, which looked like large heaps of black rock, increased from day to day, moving at the same time horizontally from north-west to south-east, as shown by accurate geometrical measurements. In April, the progress of the field of lava of Aphroessa† was principally in a northerly direction, menacing thus to block up entirely the small harbour of St. George. In the beginning of May it became every day more apparent that the mass of lava had changed the direction of its onward movement, taking its course now to the south-west, in the direction of Palea Kaimeni." By the 30th of May the new islands had increased to four, and they represented the emergent portions of the lava currents, which had filled a deep sea-trough between Nea and Palea Kaimeni.

The displacement of the May islands is highly curious. Our authors describe them as made up of wildly accumulated and brittle blocks, and they regard their onward movement as indicating "not only a greater extension of the igneous mass at the bottom of the sea, but also a displacement and destruc-

* Rather more than 2187 yards, or exceeding a mile and a quarter.
† The name of a part of one of the islands.

tion of the yielding material in a much higher degree than that occasioned by the breakers." In actions of this kind they find an explanation of the increase and decrease and total disappearance of such islands.

The paper from which we have extracted the preceding information is illustrated by four large plates; the first is a reduction of the Admiralty chart of the Santorin group, with soundings of the adjacent waters; the second is a map, showing the successive enlargement of Nea Kaimeni; the third (called Plate II.) is a remarkably beautiful and interesting photograph of a model of the island and adjacent sea-bed, made by Herr Stübel; the fourth (called Plate III.) contains two fine photographs, one depicting a bird's-eye view of the island, previous to the eruption of 1866, and the other exhibiting their configuration after it, and showing the column of steam rising from the volcanic vents. These illustrations are very instructive, and will be highly esteemed by students of volcanic action.

JUPITER WITHOUT SATELLITES.

On the 21st of August the remarkable spectacle of Jupiter without his attendant satellites gratified the eyes of numerous observers. In London the weather was scarcely propitious, as a number of clouds were flitting slowly across the sky, and, at convenient hours, only occasional glimpses of the planet could be obtained. In some other localities a cloudless sky offered greater facilities, but those who were only favoured with intermittent views had much reason to be gratified with the singularity and beauty of the spectacle.

Of course the phrase, "Jupiter without satellites," is not literally true. The satellites had not forsaken their primary, but, by a series of remarkable coincidences, they all ceased for an hour and three-quarters to occupy visible positions at his sides; so that, in any telescope not powerful enough to show the shadows, or the bodies of those that were on his disk, his luminous globe appeared wandering alone.

Jupiter is an enormous planet, the largest of our system, being 1300 times as big as our earth, and having a diameter of no less than 87,000 miles. Mr. Breen, in his "Planetary Worlds," makes the following concise remarks respecting the four satellites of this wondrous globe. He says, "The three inner satellites move all very nearly in the plane of the equator; but the fourth is slightly inclined to it. In consequence of this, and their proximity to Jupiter, the three first

satellites are eclipsed at each revolution, which does not happen to the fourth, as it can pass above or below the shadow. Passing between Jupiter and the sun, they likewise produce solar eclipses, and their shadows on the disk can be seen in the form of round dark spots, and in powerful telescopes even the satellites themselves are visible. Some very curious laws have been detected by the combination of the motions of the three interior satellites, and it is impossible that they can all be eclipsed at the same time. On some extraordinarily rare occasions, however, Jupiter has been seen without any satellites. They are not necessarily *eclipsed* on that account, as they may pass either before or behind the disk. The three interior satellites return to nearly the same position in respect to Jupiter in a period of 437 days 4 hours."

Jupiter is composed of much lighter materials than our earth, his density being 243 when that of the Earth is reckoned at 1000; but from his great size he is able to exert a great power of attraction, and a body which would weigh 100 lbs. on the Earth would weigh 224 lbs. at Jupiter's equator, and as much as 276 at his poles. Jupiter's diurnal rotation takes place in a few minutes less than ten hours; so that his atmospheric currents resulting from rotation must be extremely violent—a fact which helps to explain the occasional rapid changes in his belts, which are supposed to be the body of the planet seen through his clouds, but which makes it more difficult to account for the frequent persistence of those belts in nearly the same condition for considerable periods. The first of Jupiter's satellites has a diameter of 2400, and is about the density of water; the second satellite is somewhat less in bulk, being 2190 miles in diameter, and thus resembles our moon in size: its density is greater than that of the other three, or of the planet himself; the third satellite is 3580 miles in diameter; and the fourth 3060 miles. Their distances from Jupiter's centre are, respectively, 278,542 miles, 442,904 miles, 706,714 miles, and 1,242,619. They revolve round their primary in periods varying from 1 day 18h. 27m. 33·505s., the time of the first, to 16 days 16h. 32m. 11·271s., the time of the fourth.

From the preceding facts, it will be seen why the positions of the satellites change so constantly and so quickly. On the 21st of August their motions were so curiously combined, that three satellites were on the disk of the planet at the same time, and a fourth behind it. The appearance of the first satellite gliding on to the disk at 10.4 P.M. was extremely beautiful as we observed it. The first contact, the gradual passage, the slight addition to the planet's margin as the last portion of the satellite's disk passed inwards, was beautifully shown in one of

the Browning-With silvered-mirror telescopes, with a power of 120.

When the cloudless intervals permitted, the shadows of the three satellites (1, 3, and 4) on the disk were sharp, and as black as ink, contrasting boldly with the brilliant portions of the planet, and making the coppery tint of the belts more conspicuous by their deviation from the much darker shadow tones. Fortunate observers saw the entrance of the third satellite on Jupiter's disk at 8.14 P.M., eclipse of the second satellite, the entry of the fourth and first on the disk, preceded by their shadows, the passage off the disk of these satellites and their shadows, and also the reappearance of the second satellite from behind Jupiter. Few could expect to be so lucky as to see all the incidents, which a perfect continuance of fine weather could disclose; but a great many saw enough to make the evening of the 21st of August memorable in their astronomical experience. Near Dublin, the Hon. Mrs. Ward informs us the sky was propitious for nearly the whole time, though clouded when the fourth satellite left the disk, and the series of phenomena ended.

IRRITABILITY OF PLANTS.

BY M. CH. BLONDEAU.

(*From "Comptes Rendus."*)

We have undertaken, in the course of this year, a number of experiments on the irritability of plants, which show that the faculty which some of them, and especially the sensitive plant, possesses of executing movements which appear voluntary, may be suspended by many agents, such as ether, chloroform, carbonic oxide, and spirit of turpentine—all of which are known to act upon the nervous system of animals.

Amongst these experiments, one appears to us of sufficient interest to deserve the attention of the Academy of Science; it relates to the action of the electric current on the *Mimosa pudica* (sensitive plant).

We selected four plants perfectly developed, and so sensitive that the slightest contact, such as the friction of a fly's wing, caused their leaves to shut up, and the petioles (leaf stalks) to droop along their stems. Placing the pots containing these plants on an insulating stand, we attached to the two ends of their stems a small copper wire in order to pass through them the current from a single Bunsen's cell. After a few seconds, when the plants reopened their leaves, and erected

their petioles, we caused the current to traverse them; but the leaves did not fold up, the petioles did not fall, and the plants seemed insensible to the electric action. We then varied the experiment, and instead of employing the direct current of the battery, we used an induced current obtained by the aid of a very small Ruhmkorff's coil. The results were then quite different. Scarcely had the current commenced when the leaflets began to fold together, and the leaf-stalks drooped down along the stems. These movements were quickly propagated from one end to the other of the plants. According to this experiment the plants are sensible to electric disturbances, and behave under such conditions like animals.

We then wished to see whether the application of the electricity for a longer or shorter time would give rise to any special phenomena, and we exposed three of the plants to electric action for varying periods. The first plant received the current from the Ruhmkorff coil for five minutes, and was then left to itself. For more than a quarter of an hour it remained in a state of prostration, but gradually its leaflets reopened, the leaf-stems lifted themselves up, and in about an hour it reassumed its natural appearance, and seemed none the worse for the shocks it had received.

A second plant was similarly treated for ten minutes, and then left alone. The state of prostration in this case lasted for an hour, and it was not till the expiration of that time that the leaflets began to open, and the leaf-stalks to rise, and these movements seemed to be accomplished with greater difficulty than in the preceding case. The plant was evidently fatigued, and did not fully recover for two hours and a half. The third plant was electrified for twenty-five minutes and then left to itself. In this case we waited in vain for its restoration—the prolonged electric action had destroyed its irritability, and even its life, for the next day we found it withered, and blackened, as if struck by lightning.

The fourth plant was reserved for an experiment which proves that electric disturbance acts upon plants, as it does upon animals. It is known that man, and other animals, exposed to the anæsthetic action of ether, become insensible to induction currents, even when strong. We desired to ascertain if it was the same with the sensitive plant. With this object in view we placed a plant under a bell-glass with two openings, through which two copper wires could convey the electric current to it. A few drops of ether were sprinkled in the glass, and in a short time the plant experienced the anæsthetic action of that substance, for when shaken it did not close its leaves, or manifest any sensibility. In this state we passed the induction current through it, but it gave no sign of

sensitiveness. The petioles remained straight, and the leaflets continued open.

These fresh experiments came in aid of others which have been made on the same subject, and supply an argument in favour of those who consider the movements observed in these plants to be produced by the operation of organs analogous to those which animals possess.

ARCHÆOLOGIA.

THE past month has witnessed the congresses, or annual meetings, of the three great ARCHÆOLOGICAL ASSOCIATED BODIES, the British Archæological Association, the Archæological Institute (the branch, or rather division, from the former), and the Cambrian Archæological Association, which was formed on the model of the first. We have stated, on a former occasion, that the three Associations had, quite unknown to each other, selected the same place of meeting, Hereford, for the present year; but that, as the Cambrian Association, by the prior publication of its claim, had secured the right to Hereford, the two others were obliged to seek their fortunes elsewhere. The British Archæological Association announced its intention of meeting at Ludlow, in Shropshire; and its congress was accordingly held during the week, from the 29th of July to the 3rd of August, under the presidency of Sir Charles H. Rous Boughton, Bart., of Downton Hall, near Ludlow—an old member, and one of the Vice-Presidents of the Association. The Archæological Institute (very unadvisedly, we think) chose to meet at Hull during the same week which had been previously chosen for the meeting of the older body, the British Archæological Association. The Cambrian Association met at Hereford from Monday, August 12th, to Saturday, August 17th, under the presidency of Lord Saye and Sele, who was compelled, by unavoidable causes, to depute his authority to the Rev. Archer Clive, of Whitfield. As a tolerably numerous meeting, which everybody enjoyed, and which gave satisfaction to all concerned in it, that of the Archæological Association appears to have been the most successful. It may be questioned if any one of these meetings has added to our archæological knowledge, or even if such meetings generally have that effect; but they are pleasant reunions, in which people who are more or less attached to the same pursuits meet and commune together. They have the tendency, perhaps, to make people talk on antiquities instead of studying them, or rather before studying; but this inconvenience is somewhat compensated by the circumstance that they excite a local feeling of interest in the numerous monuments of antiquity which still exist, and many of which have been exposed to the risk of destruction through local ignorance.

The meeting of the Cambrian Association was made the occasion

of excavations into a very large TUMULUS at Thruxton, by the directions of the Rev. Archer Clive, of Whitfield, on whose estate it stands. Thruxton is a village about eight miles to the south-west of Hereford. The tumulus resembles the larger monument of the same class at St. Weonard's, farther to the south of Hereford, which was opened a few years ago under the direction of Mr. T. Wright, and an account of which will be found in the first volume of his "Essays on Archæological Subjects." Mr. Wright was at Thruxton two or three days before the meeting, after the men had been set to work excavating, and gave some directions, or suggestions, which seem to have been followed; but the examination has evidently been as yet very imperfect. There appears to have been in the centre of the mound a small dome of stones, which covered a mass of ashes, the result of the cremation of the dead body, just the same as was found to be the case in the great barrow at St. Weonard's. One or two pieces of pottery, Roman in character; parts of an iron horseshoe; and a portion of a glass vessel—the latter very improperly carried away by some accidental visitor—were among the remains found in the tumulus. It is to be hoped that whoever has the glass will immediately restore it, as it may be of very great importance in establishing the true character of the monument. All the evidence yet obtained leads us to believe that it belongs to the Roman period, and points to its identity of character with the tumulus at St. Weonard's, and several other large tumuli on this border. This at Thruxton, like many of the others, stands very near the parish church. This circumstance admits of an easy explanation. These barrows were, no doubt, in early times, looked upon with a large amount of superstitious veneration by the population of the neighbourhood, and people probably assembled at them at different periods. The early Christian missionaries sought to turn these assemblages of people to account by erecting their church near to the tumulus, and so draw the attention of the people assembled there to their preaching.

We are very glad to be able to announce that the excavations at Wroxeter, on the site of the ROMAN CITY OF URICONIUM, are recommenced. We owe this chiefly to the munificent liberality of Joseph Mayer, of Liverpool, who recently made a very handsome contribution of £50 to the excavation funds. It is to be hoped that others will follow his example, and that the good work will not again meet with so long an interruption; though it will never be carried to the extent which the history of our country requires, until the Government itself steps forward to supply sufficient funds. Through a mistake in the first measuring out of the land which the Duke of Cleveland granted for excavating, the greater part of the line of the Old Wall, or the wall which divided the Basilica from the Baths and other buildings to the south, was left out of the limits; the consequence of which was that some important buildings could not be explored in a satisfactory manner. This has now been remedied, and a large room has been opened, which fronted the Forum, and adjoined the room which has been called the enameller's shop. The portion of this room yet uncovered is of small

extent, for it was found necessary to withdraw the men for the requirements of the harvest; but enough has been done to show that it is possessed of very considerable interest. It appears also to have been a workshop, for the remains of erections built of stone, somewhat like forges, have already been found; and amongst the loose objects scattered about the floor was the bowl of an iron ladle, which appeared to have been used for pouring out melted metal. Among the other articles which have been gathered from the small extent of excavation yet made, are a great quantity of earthenware and glass—some of the latter of very interesting character; and, among the pottery, two handsome ornamental bowls of Samian ware; two iron rings; a very curious finger-ring, made of amber; a bronze fibula; an ornamented bone roundel; a bronze scale-pan, with three equidistant holes; two hair-pins; a small pellet of enamel; a white disk of bone, like a button, but without a shank; nine Roman coins; and a piece of sandstone, with a fragment of an inscription. The buried part of the Old Wall has also been uncovered, and all that has been yet done, though very small in extent, gives promise of important discoveries.

A very remarkable discovery has recently been made on the site of Wigmore Abbey, in Herefordshire. In digging for some works of construction, the workmen came among some very extraordinary subterranean buildings, which soon assumed the form of a very large passage, wide and lofty, and was followed for, we believe, at least a hundred feet; and, with the old legendary notions about abbeys and castles, was assumed to be a passage for secret communication between Wigmore Abbey and Wigmore Castle, a distance of about a mile and a half. However, a little consideration was sufficient to convince us that it was simply the great drain of the important Abbey of Wigmore; and, as such, it is a very remarkable monument of the internal economy of these great mediæval establishments. T. W.

PROGRESS OF INVENTION.

Improved Application of Superheated Steam.—It is found more economical, as far as fuel is concerned, to increase the pressure of steam by superheating it, than by causing the evaporation of an additional quantity of water. There is a limit, however, to the degree of temperature to which the superheated steam can be raised: since, if its temperature is too high, lubrication will be imperfect, or impossible, on account of the charring of the oil. Superheating is applied very effectually in a new engine recently constructed for the water supply of the city of Paris. This, like Woolf's engine, consists of two cylinders, the steam passing from one into the other; but instead of the steam passing directly from one cylinder to the other, after leaving the first, it is made to traverse tubes which are placed in the furnace near the chimney.

Thus, the steam is not only heated to the temperature it had when it entered the first cylinder, and therefore has no tendency to lose its vaporous form, but it is superheated, so as to have an increased pressure. And this restoration of heat, and superheating, is the source of the greater economy, as the heat required for the purpose costs nothing, being taken from the products of combustion just before they are about to escape into the chimney, and to carry off and waste any heat still remaining in them.

Combination of Horse and Steam Power for Locomotives on Ordinary Roads.—The great difficulty attending the introduction of steam on ordinary roads, as far as the public is concerned, is the danger of accidents of a most serious kind from the least interruption of attention on the part of the engineer in charge of the vehicle. On a curved or crowded road there must be constant changes of direction, without which collisions, or other dangerous effects, will certainly take place. With a vehicle drawn by horses, their intelligence, not less than that of the driver, is effective; and in cases in which the driver is negligent, or even incapable, from sleep, or some other cause, the horses may, and often do, bring the vehicle safe through every peril. This consideration has suggested the utilization of the intelligence of the horse—which, unlike that of the engine-driver, is undoubtedly ever occupied only with things present—by a means which M. Séguier has recently brought under the notice of the Academy of Sciences. The horse is to be attached to the locomotive, not for the purpose of giving the least assistance in drawing the vehicle, but with the sole object of aiding in its guidance: it will therefore undergo no fatigue. A shaft, which is placed in front of the steam-carriage, and to which the horse is yoked, is so connected with the steam machinery, that when the horse advances, the steam is turned on, when he moves back, it is turned off; and when he turns to either side, the mechanism required to turn the carriage in the proper direction is thrown into action.

Renovation of the Polished Surface of Glass.—Hydrofluoric acid in the form of gas, and that dissolved in water, has very different effects on glass. As a gas, it entirely removes the polish, rendering the glass incapable of transmitting the images of objects; as an aqueous solution, it removes the old surface, without destroying the polish, but, on the contrary, rendering it more brilliant. For this purpose a very dilute acid must be employed; if tolerably concentrated, it will eat a hole in the surface of the glass on which it is placed; but this hole will have a brilliant appearance. This property, possessed by hydrofluoric acid in solution, has suggested it as an excellent material for cleaning glass which has been tarnished by time or bad usage.

Application of Electro-Magnetism to the Manufacture of Iron.—It has been found by recent experiments that electro-magnetism can be used with excellent effect in the manufacture of iron; the process being facilitated, and rendered more perfect, while, at the same time, fuel is economized. An opening is made in the smelting furnace, and opposite to this opening is placed an electro-magnet,

which is excited by a current that is made to traverse the iron while in a state of fusion. Numerous gas bubbles are produced, and the resulting iron is harder and more tenacious than what is manufactured in the ordinary way.

Application of Sulphuret of Carbon to the Extraction of Oleaginous Matters on the Large Scale.—In France there are two great sources of waste of oleaginous and fatty substances. Vast quantities of oil remain in the olives, however much they may be pressed; and enormous quantities of soap, after having been used in the silk manufactories, pass off into the rivers and are lost. Both these sources of waste are now about to cease, on account of the industrial applications of sulphuret of carbon—a substance which possesses an extraordinary power of taking up fatty matters, from which it is separated with great facility by distillation. As long as it was dear, its application in this way was impossible; from improved methods of manufacture it is now become extremely cheap; and almost none of it is lost during its application even on the large scale. The sulphuret of carbon is allowed to flow through the olives, partially exhausted by pressure, to a still, whence it passes to a new quantity of olives; the process being continuous, and so perfect that the very presence of the sulphuret is not to be perceived in the establishment. The olives, completely exhausted by the sulphuret, are far more effective as manure than those from which the oil has been only imperfectly separated. Applied to a saving of the soap refuse of the silk manufactories, several thousands of tons of that valuable material will be recovered annually. Large quantities of the regenerated soap have already come into use.

Further Utilization of Aluminium Bronze.—Bronze containing ten per cent. aluminium and ninety per cent. copper, has been found to possess the invaluable property of being almost indestructible in the working parts of machinery exposed to great wear and tear. This is illustrated by a purpose to which it has recently been applied in France. Paper, and especially when coated with dried gum, is rapidly destructive of the best cutting instruments, and the parts of the machine connected with them. Holes for rendering French postage-stamps easily separable, one from another, are made by an instrument having three hundred needles, that descend through the five layers of postage-stamps lying under them into holes which have been carefully made in a steel plate placed beneath. In one day, the steel plate is worn to such a degree that afterwards, instead of the holes being punched in the paper, the latter is merely crumpled into the holes in the plate, and more or less injured. A plate of aluminium bronze having been substituted for the steel plate, it was found to last for fifteen hundred days without requiring any repair, having received daily one hundred and twenty thousand blows. Hitherto the utility of aluminium bronze was limited by the difficulty with which it was soldered; ordinary solder does not answer for the purpose. It has, however, been found, that one piece of aluminium bronze may be easily and firmly united to another, or to iron, either cast or malleable, by means of

a mixture of common tin solder and an amalgam of zinc and mercury. The proportions may vary from equal weights of tin solder and amalgam to one part amalgam and three parts tin solder.

PRESERVATION OF LIQUORS CONTAINING ALCOHOL.—Liquors, such as beer, containing comparatively small quantities of alcohol, have a great tendency to natural fermentation. It has been found that this tendency may be lessened, and even destroyed, by a judicious application of heat. The higher the temperature, the more effective it is; but unless kept within certain limits, the flavour will be deteriorated, or even destroyed—a disagreeable one supervening. It is enough if a temperature at all higher than 45° Cent. is reached; but that between 28° and 58° must be allowed to continue for as short a time as possible, since the various temperatures between these points are exactly those most favourable to the development of natural fermentation. The temperature should be raised as rapidly as possible to between 48° and 58°, which should be maintained for at least twenty, and at most sixty, minutes; after which the cooling should be rapid, and the liquor should then be transmitted to barrels which have been previously filled with carbonic acid.

NEW APPLICATION OF ELECTRICITY.—It is necessary that the person attending on a power-loom should carefully watch and remedy the breaking of a thread; and as several looms may be in charge of one attendant, it would be very useful that his attention should be directed to a broken thread. This is now done with great simplicity and certainty in the case of the stocking-machine, by means of electricity; and there is no reason why the same contrivance should not be applicable in other cases. A small lever rests on the thread, and retains its position as long as the thread is whole. But the instant the thread breaks, the lever falls, and completes connection between the poles of a galvanic battery, which excites a small electro-magnet, and sets a bell-ringing apparatus in action. This attracts the notice of the attendant, so that the broken thread is instantly made whole again.

THE LATENT IMAGE.—The photographer had long been surprised at, but unable to explain, the existence of the latent image; and its development has never failed to astonish the uninitiated—its appearance being something resembling the effects of magic. Its nature, thanks to Mr. Carey Lea, is no longer a mystery; and its existence is shown to be due to well-known optical principles. There are certain substances which, in contact with organic matters (thus, iodide of silver), undergo a marked chemical change when exposed to the action of light. It was considered that the presence of the luminous body itself was required to produce this effect, which is not, however, the case. It has long been known that certain substances are capable of absorbing light and again emitting it—some in a few seconds, some during a much longer period. It is true that this fact was remarked only regarding the luminous rays; but we might infer it from analogy with regard to the actinic rays also; and there is no question of it regarding the calorific. It explains, indeed, the fact, that an engraving exposed for a few

minutes to light, and then placed in contact with sensitized paper in the dark, will give rise, on development, to an image. Applying this principle, we shall find that a latent image must result when iodide of silver, for example, is exposed to light along with some substance capable of absorbing light, and retaining it for a sufficient length of time, and is then, before the light has been all emitted, placed in contact with the requisite organic matter. The conditions necessary for the production of the chemical changes indispensable to the obtaining a picture are fulfilled; since the iodide of silver and the organic matter are simultaneously in presence of light, though not of the luminous body.

Electric Condition of Different Parts of the Earth.—It has been found that, if one extremity of a long wire is inserted in the earth at one place, and the other in the earth at another place which is higher than the former, a current of electricity will constantly traverse the wire from the lower to the higher level. This fact has been recently explained by M. Matteucci, and his explanation has been experimentally illustrated by him. It is a consequence of the positive electricity constantly carried towards the poles by the wind, and the inductive action of this electricity on the earth. The stratum of air near the earth, especially over seas and lakes, is continually being neutralized, but the neutralization goes on more slowly and imperfectly in mountainous and even slightly elevated regions. Hence the mountain and the air in contact with it are in opposite electrical states of greater intensity, and thus it is that clouds are so strongly attracted by mountains. The mountain and the plains are negatively electrified, but not in an equal degree; and if their electricity is not in a static condition, a conductor must lead a current from one to the other. They are not in a statical condition; for neutralization of the air in contact with the earth is constantly taking place, and electrical equilibrium is therefore constantly being disturbed. This is illustrated by M. Matteucci by a very simple and satisfactory experiment. He places a globe, made of porous earth or of wood, covered with moistened blotting-paper, on an insulating stand; fixes a small metallic disk on the highest part of the globe, and in contact with the moistened blotting-paper, and a similar disk from fifty to ninety degrees from the first; then, having connected the plates with a galvanometer, he electrifies the globe. No current is, under these circumstances, indicated by the galvanometer; for the electricity of the globe is in a static condition. He next suspends, by an insulator, a small, slightly concave metallic plate over the higher disk, and about an inch from it. This concave plate represents the atmosphere; and if it is placed in connection with one conductor of the electrifying machine, and the globe with the other conductor, so as to oppositely electrify the globe and the plate, the galvanometer will, on turning the electrifying machine, at once indicate the presence of a current. The electric condition of the globe is different at different parts; and it is no longer static, for the electricity of the globe is constantly passing to and neutralizing that of the plate. It is not always necessary that the extremities of a long insulated wire, in-

serted in the earth, should be at different levels, in order that a current should be developed in it, since the positive electricity of the air increases as the poles are approached; and hence, in a similar way, the negative electricity of the earth produced by inductions. There is, therefore, usually a difference of intensity between the earth at the poles and at the equator; and as the electric state is not static, a wire in a direction from the equator to either pole should indicate a current, which experiment shows actually to take place.

PHOTOGRAPHIC MARINERS' COMPASS.—A simple means of registering a ship's course by photography has recently been invented. The instrument employed is the compass by which the vessel is steered, modified for the purpose. A small aperture is made in the line representing the north on the card, and in it is placed a lens. Under the card is sensitized paper, which is made, by clockwork, to pass along with a regulated speed. Were the vessel constantly to move in the plane of the magnetic meridian, the paper, after development, would show a straight line, of a length dependent on the time of the voyage; but every deviation to the east or west will be marked, by the light which illuminates the compass, on the paper, which moves under the aperture in the card, the latter being immovable. If the paper is divided by transverse lines, the length of time during which the vessel was steered in any particular direction will be indicated by the corresponding deviations from a line corresponding with the intersection of the planes of the magnetic meridian and the horizon.

LITERARY NOTICES.

OUTLINE LUNAR MAP. Zones II. and IV. Areas IV. α and IV. ζ, with Catalogue of two hundred and three objects, the whole deduced from Photographs, Observations, and Measurement, by W. R. BIRT, F.R.A.S. Under the direction of the Lunar Committee of the British Association. (From the Report of the British Association for the Advancement of Science, for 1866.) (Printed for private circulation.) —Mr. Birt, the Secretary of the British Association Moon Committee has evidently made his arduous and laborious task a labour of love, and the positions of the great map comprised in Zones II. and IV., areas IV. α and IV. ζ, now issued together with the elaborate, accompanying, and explanatory, pamphlet, bear ample testimony to the value of his work. The pamphlet states that "the scale of two hundred inches in the moon's diameter appears to be the *smallest* that can be used with advantage in the present state of selenography." This dictum embodies the deliberate opinion of the distinguished astronomers who form the committee, and must therefore be received with great respect. No doubt much may be said for it; but as few observers have any opportunity of seeing portions of the moon on anything like so large a

scale, and as the majority of observations are necessarily made under a magnification which is only a small fraction of that supposed by a map of the lunar disk nearly seventeen feet in diameter, the scale selected is not without serious difficulties. It certainly gives plenty of room for "inserting synonyms" and "numerical data," but renders objects seen under moderate powers difficult of identification, and tends to induce observers to draw them on a scale disproportionate to the amount of detail actually seen. The "best possible scale," for the purpose will be estimated differently by various observers; but all agree in appreciating Mr. Birt's work, which is to supply a series of lunar map sections, carefully drawn to scale, and exhibiting contour lines of the various formations.

The nature of each object is indicated by a symbol which is explained in the Report of the Moon Committee for 1865, and there is no attempt at a minute exactness not possible until a much larger accumulation of facts has been made. Mr. Birt rightly describes his charts as "a guide to observers in obtaining data for the construction of a complete map." He adds, "at present the engraved portions of the map are in *outline*, and will doubtless require *considerable modification*, as observers work at the subzones which they may select." Mr. Birt also recommends observers to tint or colour their subzones, so as to make craters and other objects more conspicuous than they are in the simple red outlines which he provides, and which are printed in that colour to distinguish them readily from any corrections or additions which observers may make in black ink. It would require a series of elaborate notices to do justice to the numerous suggestions and important bits of information which Mr. Birt supplies concerning the zones and areas comprised in his map, and we can only observe that they are calculated to render most valuable aid to lunar students.

It will be very interesting to compare the physical geography of the earth and moon, and to notice how the distribution of hollows, elevations, etc., vary in the two bodies whose surfaces have assumed their existing forms under such different conditions as are expressed by the presence, and absence, of water and air, and numerous observations will be found in Mr. Birt's pamphlet, which will materially facilitate researches of this kind. We would take this opportunity of urging the British Association Committee to lose no time in providing Mr. Birt with a telescope of suitable dimensions. The small instrument which he is at present using is not half the diameter of that which he ought to have to justify his drawing his contour lines on so large a scale, and can supply no means of testing the observations of difficult objects that may be communicated to him by other observers.

AUVERGNE: ITS THERMO-MINERAL SPRINGS, CLIMATE, AND SCENERY. A Salutary Retreat for Invalids. By ROBERT CROSS, M.D., Edin. and Heidel, F.R.C.P., Ed., and M.R.C.S.E., Author of "Physiology of Human Nature. (Hardwicke.)—Geologists have long been familiar with the Auvergne as a district remarkable for its illustration of volcanic action, and for the numerous extinct craters which

it contains. A few tourists are likewise familiar with its magnificent scenery, and now comes an accomplished physician to recommend it to the attention of invalids for its baths and medicinal springs. From the analyses of the various waters which Dr. Cross cites, there can be no doubt of the high claims of the district to share with better known localities in the treatment of the swarm of patients who anxiously seek to recruit their health with prescriptions prepared in Nature's pharmaceutical laboratories; and we confess a strong sympathy with the æsthetic sensibilities of those who prefer to be made well in beautiful localities. Rheumatism can rejoice in brimstone, scrofula and cancer can be mollified with arsenic, and weak digestions excited by salines and tonics in this wondrous land of extinct volcanoes, where the subterraneous fires are constantly employed in boiling invisible pots, and effecting combinations which would puzzle the apothecary to imitate, and which we do not doubt possess peculiar efficacy in a host of other ailments. Dr. Cross discourses on these subjects with the tact and moderation of a man of science, and his elegant little volume is embellished by views of the principal places where accommodation for invalids can be obtained. He also supplies a useful body of "guide-book information" in a gentlemanly and scholar-like style. As an illustration of the efficacy of arsenic in the treatment of cancer he mentions the following case which occurred in his own practice, the patient alluded to having suffered from that malady, though the consultation he describes was necessitated by other symptoms, which suggested the idea of arsenical poisoning, and this was confirmed by an examination of the paper of her bed-room recently renovated. Removed to another apartment she recovered slowly from its effects. "Meanwhile the pain, hæmorrhages and fetid discharge of her original complaint had been so completely suspended, that her attention had been entirely directed to her new malady; the arsenical disease had, in fact, superseded the cancerous. As the former, however, subsided, the latter came again into activity; and being now far advanced, very soon afterwards came to a fatal termination." The doctor adds, that he intends to suggest a trial of the Bourboule springs at an earlier stage of a similar complaint. At St. Nectaire the baths are supplied with an apparatus for the employment of carbonic acid douches, "found efficacious in neuralgic affections and muscular rheumatism." Some of the Auvergne springs resemble those of Germany, Royal being like Ems, St. Nectaire like Carlsbad, and many resembling Vichy; Puy la Poix are similar, but more powerful than the sulphur springs of the Pyrenees; but the arsenical water of Bourboule, Dr. Cross considers to be without a rival in their peculiar way.

Symon's Monthly Meteorological Magazine. August, 1867. (Stanford.)—The first article in this number relates to the excessive rainfall of July 26th, which is stated to have been as remarkable as any that has occurred of late years, "Excepting the remarkable case in 1857, when on August 6th a waterspout burst over Scarborough, and the rain-gauge which held nine inches was filled and found running over; and 1864, May 20th, when at West Retford,

Notts, 3·10 inches fell in 2¼ hours, we can recall no rains more noteworthy than those which have lately fallen." Mr. Symon adds, "the facts appears to show that the heaviest fall was an excessively local one of about five inches, extending along the north side of the North Downs from Farningham nearly to Sittingbourne; Rochester, Chatham, and Strood, being on the northern limit of excessive fall. It was accompanied by a violent thunder-storm, which was most severe between Faversham and Canterbury; thirty-two sheep were killed by lightning near the latter city. About the same hour it was raining very heavily at Deptford and Greenwich, where about four inches of rain fell. Nearly four inches fell at Billericay, in Essex." Mr. Symon's also informs us that nearly twice as much rain fell at Deptford as at Camden Town; and he notes other cases in which the variation was similar between places only a few miles off. Amongst the correspondence to the "Meteorological Magazine," Mr. Blackmore, of Teddington, remarks, that the storm of the 26th was prenotified by the remarkable appearance of the sky on the evening of the 24th, when the south-east sky exhibited "a beautiful fan of blue divergent radii rising 30° above the horizon, streaking across the redness like a windmill with blue sails to it." Mr. Symon says that a friend sent him a sketch of a similar appearance seen in Kentish Town on the 25th.

NOTES AND MEMORANDA.

VERIFICATION OF SEXTANTS.—It is a disgrace to the mercantile marine that the majority of the sextants with which their captains are supplied, and on which their safe navigation often depends, are of the most worthless description. First-class opticians, of course, supply reliable instruments, but ordinary sextant making has sunk so low as to resemble the worst sort of tailors' slop-work, and the operatives engaged in this wretched business are miserably paid. The British Association Observatory at Kew supplies the means of curing this evil, by testing the instruments, and the apparatus now employed for this purpose, designed and constructed by Mr. F. Cooke, is described in the "Proc. Roy. Soc.," No. 94.

EXPERIMENTS WITH THE RIGID SPECTROSCOPE.—Some time ago, we described the general construction of the rigid spectroscope, made by Mr. Browning for Mr. Gassiot, in order to test a suggestion of Mr. Balfour Stewart, that the position of spectrum lines might be slightly affected by changes in terrestrial attraction consequent on approaching to or receding from the poles. The instrument was sent out in the surveying-ship "Nassau," and Mr. Gassiot has recently communicated to the Royal Society the report of Captain Mayne, together with remarks thereon by Prof. Stokes and Mr. Balfour Stewart. The report says that the micrometric reading increased as the barometer fell, and *vice versa;* it was also affected by temperature. After deducting all other ascertainable sources of change, it seems as if the difference of the earth's attraction between lat. 45° and the equator may change the readings for the yellow of the spectrum to an extent equal to about ¼ of the interval of the D lines. Prof. Stokes thinks this slight change may arise from other causes than difference in gravitation; and Mr. Stewart, though regarding it as arising from that source, does not consider the experiments conclusive. Further information is therefore looked for with much interest, as, when stripped from technicalities, the question to be decided is,

whether or not light is to be regarded as the vibrations of an imponderable material.

Constitution of Sun and Stars.—Mr. G. J. Stoney has a remarkable paper in "Proc. Roy. Soc.," No. 94, disclosing speculations on this subject, to which he assigns varying degrees of probability. He remarks, that if, as is probable, the sun's atmosphere decreases in temperature from within outwards, the gases with the lightest particles will be uppermost, and the heavier ones lower, and these layers of gases will be of different temperatures, hydrogen being the coldest. Observation, he thinks, confirms this view, "the rays of hydrogen, sodium, and magnesium emanate from a region so cold, that the lines of these elements in the sun's speculum are intensely black;" while "calcium, iron, and the rest, while they produce only black lines in the violet and indigo, give rise to lines which are sensibly less dark in the blue, and to lines which emit a still more considerable light in the green, yellow, orange, and red—those colours in which a body gradually heated begins to glow. Hydrogen and iron are the two most abundant constituents of the sun's outer atmosphere, and play in it the same part which nitrogen and oxygen do in the earth's." The photosphere consists of two strata, the outer one of cloud, that is solid or liquid matter in minute division, and denser than the atmosphere in which it is dispersed. Cooling by radiation, these clouds rain down their materials as our water clouds do theirs. This cooling he believes to give rise to a layer of minimum cloud temperature, the strata above and below being hotter. "About the middle of the hot stratum over the photosphere, outside which the temperature decreases almost continuously to the limit of the iron atmosphere." Outside this, in another stratum, he thinks the temperature falls short of the heat of a Bunsen burner; and outside this again, "through the immense height which is tenanted by sodium, magnesium, and hydrogen alone, the temperature goes on decreasing, till it becomes excessively cold." "Within the luminous clouds the temperature very rapidly waxes, and the density too appears to receive a nearly sudden increase, all gases with a vapour-density more than about eighty times that of hydrogen are imprisoned within the shell of clouds by the comparative chill which there prevails co-operating with the force of gravity exerted by the sun." Applying these theories to the stars, Mr. Stoney observes, that "when gravity on a star is feebler than on the sun, either from the mass of the star being less, or from its being so dilated by heat that its outer parts are further removed from its centre gases, which by reason of the mass of their molecules are imprisoned within the photosphere of the sun, will, when less attracted downwards, be able to stand the coolness of the shell of clouds, and pass beyond them. Thus mercury, antimony, lithium, and bisinuth, all of which have too high a vapour density to exist in the sun's outer atmosphere, show themselves in Aldebaran." Stars in which the temperature is lower, or gravitation acts with more force, will attract down dense materials from their outer atmosphere, and constitute the class of intensely white stars with a bluish tinge like *a* Lyra and Sirius. Hydrogen has so low a molecular mass, that it is thought no star exerts attractive force enough to compel it to limit to temperatures which would make it appear bright when placed upon the background of their photospheres, and hence, where hydrogen appears at all, its spectrum lines are intensely black. To account for the colours of double stars, he supposes that collisions of stars take place, and that the two stars thus meeting, emerge from the frightful conflagration that ensues as one star, or as two, having orbits that would lead to fresh collisions, or passage through each other's atmosphere, in the course of which the weaker, or companion star, would be deprived of its lighter gases, and thus emit only the colours proceeding from denser gases, blue, violet, and green.

The 92nd Planet.—On the 26th July, Dr. Peters, of Hamilton College Observatory, Clinton, U.S., discovered this body, which is of the 11th mag. It has been named Undina.

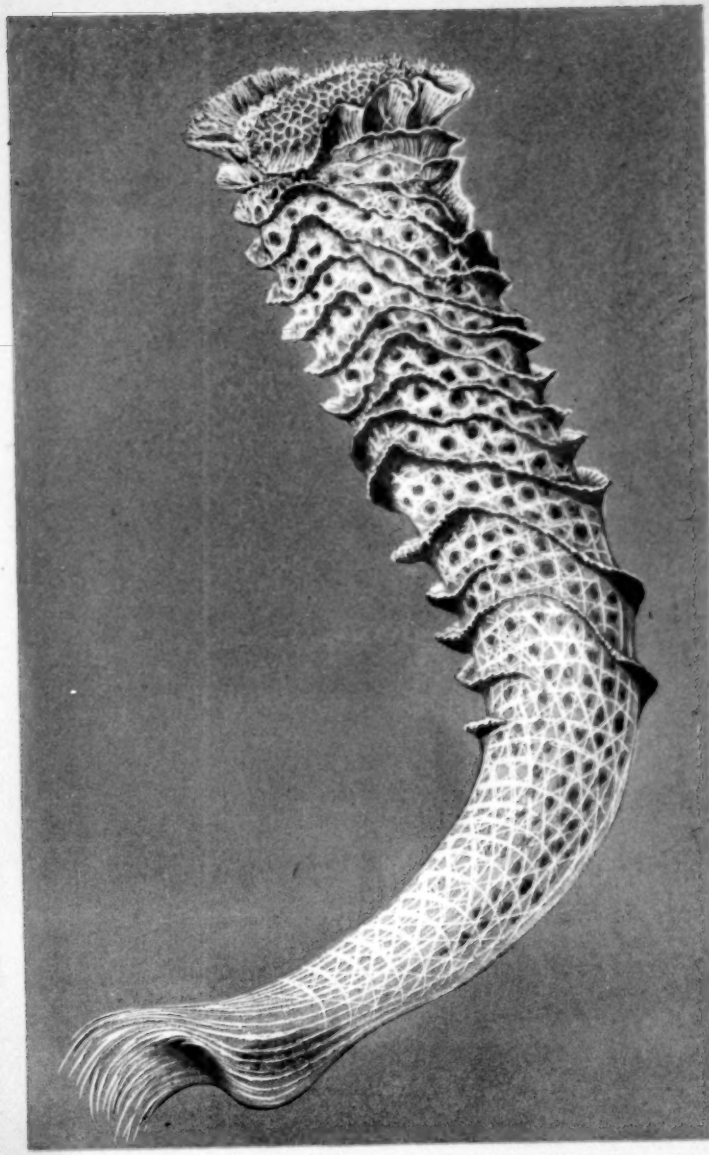
Roman Surgical Instruments.—M. H. Scoutetten describes to the French Academy a collection of surgical instruments found at Herculaneum and Pompeii. He says three hundred specimens have been collected, representing sixty different forms of instrument. Amongst others, he mentions sounds of excellent curves, and specula with two and three valves. Having obtained permission of

the Italian Government, he has had photographs made of the instruments, and also of a fresco, representing a surgeon removing, with a strong pair of pincers, an arrow from the thigh of Æneas. Ascanius stands by weeping; a group of warriors make up the background; and Glory, represented by a female figure holding flowers in her hand, approaches the hero.

PASCAL AND NEWTON.—A curious controversy is going on in the French Academy of Sciences, concerning the authenticity of a number of letters, on the strength of which M. Chasles and those who agree with him believe that Pascal communicated to Newton certain ideas which led to the discovery by the latter of the law of universal gravitation. Sir D. Brewster, in a communication to the Academy, pointed out reasons for considering these documents as forgeries. One of them purports to be from Anne Ayscough, the mother of Newton, thanking Pascal for his kindness to her son. At its date Newton was only four years old, and his mother had married again to a Mr. Smith. Pascal is also made to write to Boyle on the 16th of June, 1654, stating that he had received from Newton a treatise on the Infinitesimal Calculus. Newton was at that time only eleven, and, as Sir D. Brewster observes, knew nothing of such matters. It was not till 1661 that he began the studies which made him famous. M. Chasles endeavoured to defend the authenticity of the letters; but M. Faugère, having compared writing known to be that of Pascal with that ascribed to him in this correspondence, corroborates Sir D. Brewster's assertion of forgery. M. Bénard, in a letter to the President of the Academy, asserts that "the documents produced by M. Chasles are certainly fabrications, and clumsy ones." He asks, among other things, how Pascal could, on the 2nd of January, 1655, calculate the mass of Saturn by help of the revolutions of a satellite which was not discovered until the 25th of the month following? The question is referred to a Commission.

FALL OF AEROLITES IN ALGIERS.—On the 9th of June (1867), about half-past ten p.m., a bright light of a bolide was seen in the plain of Tadjera, by observers at various distances from each other, who also heard sounds like cannon-firing. At Bou Saâda, M. Correard, of the 3rd Tirailleurs, says the bolide appeared about 60° above the horizon, traversed 20° or 25° in from five to eight seconds, directing its course from S.E. to N.E., and ceasing to appear at 40° above the horizon. It looked about three times as big as Venus, and had a luminous train. When it burst, fragments of meteoric matter are said to have fallen, and some pieces were afterwards picked up which were believed to have come from it, as they differed in appearance from other meteoric fragments which have been found, though very rarely, in the same locality.

A PRETTY EXPERIMENT WITH WATER.—M. J. Plateau says that a cylinder of water may be made to transform itself into isolated spheres by the following means:—Take a cotton thread, about one-thirtieth of an inch in diameter, and about half a yard long; moisten it carefully by rubbing it with water; attach a small weight to one end; hold the other end in the hand, and let it sink straight down in a vessel of water. Then draw it up steadily, and the cylindrical layer of water adhering to it will divide into little globes like a string of pearls. A similar experiment may be made with oil.



SPONGE.

Euplectella speciosa.